A SECOND
DISSERTATION
ON THE
Motion of the Blood,
AND
Effects on Bleeding;

Being a Collection of Two Hundred Thirty-
five Anatomical Experiments made
on living Animals, with uſeful
Reſults therefrom.

By the Learned and Celebrated
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ERRATA.

Page 33, Line 7, after the word *and* add, *the next moment it.* Page 35, Exp. 72, Line 6, after the word *in* add the letter *d.* Page 42, Exp. 86, Line 15, inſtead of *which upon*, read *whereupon.* Page 64, Exp. 125, Line 6, inſtead of *veins* read *vein.* Exp. 126, Line 18, for *preunion* read *re-union.* Exp. 131, the laſt Line, for *veins* read *vein.* Exp. 156, Line 22, before the word *whole*, ſupply *the.* Exp. 217, Line 4, after the word *animal*, ſupply the words, *the venal blood.* In the ſame Exp. Line 11. after the words, *carried from*, ſupply, *towards*: and alſo in the ſame line, for the words, *from the inteſtines*, read, *to the inteſtines.*

THE

PREFACE.

THE Doctor preſented this Diſſertation to the Royal Society of Sciences at *Gottingen* the 26th of *March*, 1756; conſiſting, as in the Title-Page, of a Collection of Anatomical Experiments, which he delivered as Fundamentals for the Reſults he had drawn therefrom. This Diſſertation he calls a Synthetical Repreſentation of Facts: It will ſhew, by the great Diligence he hath beſtowed, that his great Deſire is to employ his exquiſite Genius and Sagacity for the Service and Benefit of his Fellow-Creatures; and therefore will remain an Honour to his Profeſſion, in imparting to the World all he hath found, by his indefatigable Labours, worthy of public Regard.

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ON

THE

SECOND DISSERTATION

ON THE

Motion of the BLOOD.

I SHALL herein, gentlemen, purſue the ſame method I made uſe of in my diſſertations on the irritable and ſenſible parts of the human body. I have the honour of dedicating to you the experiments on which I have founded my diſſertation concerning the motion of the heart and the effects of bleeding; they will ſhew that my reſults eſtabliſhed thereon, are from repeated experiments. I think this collection will be uſeful; it may prevent objections; and indeed I think it proper to produce my diſſections as teſtimonies of my veracity. I ſhall not ſet forth in theſe papers the experiments on the motion of the venal blood, nor on that of the heart; they are contained in the ſecond diſſertation, on the irritable parts in the fourth and ſeventeenth ſections; which may be conſulted,

ſulted. But herein I ſhall ſhew what I have ſeen, with reſpect to this globules, the colour, the motion of this vital fluid through the arteries and veins; the effects of bleeding, and the motions of the blood after the heart is deſtroyed, or at leaſt after its communication with the ſyſtem of the veſſels is taken away. I ſhall not produce all my experiments, and I find on examining mine with thoſe of M. Remus, that diligent obſerver of thoſe which I made in 1751, that this gentleman hath in writing taken an account of many of them which I have omitted. For being overcome with labour, and ſometimes diſliking the frequent returns of the ſame event, I began to be tired in charging my papers with the ſame.

SECTION I.

Experiments on the globules of the blood.

EXP. I. *On a little fiſh*, May 31, 1751.

M. HOLLMAN hath favoured us with a ſolar microſcope, and ſhewn me the ſurpriſing ſight of the circulation of the blood, magnified by this inſtrument. The veſſels of the tail ſeemed to form ſtreams of globules ſwiftly moving in a circular courſe of the ſize of a pea: But this ſight, although engaging, is not very inſtructive, the objects ſeem therein not well deſcribed, and their great variety of colours dazzles the eye; ſo that with reſpect to experiments thus made, and alſo with reſpect to all things in life, I think, that a medium is preferable to exceſs (*a*).

Exp. II. *On a little fiſh*, June 10.

I made uſe of the glaſs of Culpeper's microſcope, No. 1. this magnifies much leſs than the ſolar microſcope, and indeed too much; the globules appear opaque and round; what I mean is their diameters appeared equal with reſpect to each other: with reſpect to their thickneſs, it would be difficult to ſay with any certainty, whether it exceeded their other two diameters. I compared theſe globules to the little feathers of the wings of a butterfly, and found them one thouſand times ſmaller: my glaſs magnified the diameter of objects two hundred and fifty times, and made them appear of the diameter of the thirtieth or fortieth part of an inch.

As to the experiment of the blood received in a capillary (*b*) tube, ſo often mentioned by Lewenhoeck, I had no ſucceſs with it; for the tube being too much magnified by the microſcope the globules became at too great a diſtance from the glaſs, and the two lines terminating the tube was rendered too opaque.

(*a*) Exp. 4. of M. Remus, p. 40.

(*b*) M. Remus, p. 39.

Exp. III. *On a frog*, July 9.

I made uſe of the meſentery in this and all the other animals of this kind; I extended it after Lieburkuhn's manner; I made choice of a ſmall magnifier; that is to ſay, No. 3. of Culpeper's microſcope, I often at the beginning of my experiments wounded ſome conſiderable vein of the inteſtines; this perhaps may be the cauſe of the following phænomenon I obſerved this day, viz. There were in the veins of the meſentery ſpherical bodies or balls one hundred times larger than the red globules, entirely tranſparent, which followed the current of the blood extremely ſwift. I obſerved the great venal trunks filled with red globules, and between theſe trunks veſſels much ſmaller, through which globules either red or yellow moved in a ſerpentine manner. There were ſome globules very red, and there were ſome very pale, which I ſuſpected were moleculæ of ſome fluid thinner than the blood. The courſe of the red globules is circular.

Exp. IV. *On a little fiſh*, July 10.

This animal had but few globules, which were of a pale yellow colour. It ſeems to me that frogs are more proper for experiments of this nature.

Exp V. *On a frog*, July 21.

The globules of this animal were of a deep red colour, even when they moved one by one ; they were round ; they became coagulated when at reſt ; they ſeemed to me by the help of a large magnifier to form polygon net-works.

Exp. VI. *On a frog*, Auguſt 30.

I was willing to ſatisfy myſelf if in reality there was any air contained in the globules, as Keil and many others believed. I apprehended that if I brought a burning candle near the globules this internal air muſt dilate itſelf, and increaſe their bulk. I conſidered and took much notice of the ſize of the globules, which I ſaw moving in the veins of the meſentery. I brought a burning candle by degrees near the blood of the meſentery; no change appeared in their ſize, but a collection of globules which had loſt their motion diſperſed themſelves by the heat; and the ſeparated globules moved from ſide to ſide. I carried the flame ſo near as to weaken my ſight, and even to burn the meſentery, but the diameter of the globules remained unaltered.

Exp. VII. *On a frog*, the ſame day.

I made the ſame experiment on the blood in the veins that had no motion ; I diſperſed it by heat ; but the globules did not become any larger ; I obſerved between the two laminæ of the meſentery particles which I did not underſtand ; they were of a brown colour, and in motion :

motion: they had the ſhape of a worm, and were ten times ſmaller than the red globules.

Exp. VIII. *On a frog*, September 3.

After many experiments I was convinced that the natural colour of the blood globules is a deep red; yet I could not yet ſatisfy myſelf with reſpect to the globules changing their figure, although they ſeem to lengthen themſelves in their ſerpentine motion through the ſmall veſſels.

Exp. IX. *On a frog*, September 20.

I obſerved again the globules of air one thouſand times larger than thoſe of the blood, in reckoning the cubes of their diameters; they are tranſparent, and move with a conſiderable rapidity, diſcharging themſelves as the blood globules out of the wounded veſſels.

Exp. X. *On a mouſe*, September 21.

I was willing to make on this little animal the ſame experiment I had made on frogs; I bound it down, and opened its belly, and hung up the meſentery on hooks, but I could diſtinguiſh nothing; the membranes of the meſentery were much thicker than thoſe of frogs; they reſembled parchment; the blood coagulated in a moment, and I could diſtinguiſh only red and white branches, without being able to diſtinguiſh the humours; there were on the meſentery lacteal veſſels, very apparent to the naked eye.

Exp. XI. *On four frogs*, May 14, 1754.

In theſe animals and many others I had an opportunity of ſeeing the different degrees of colour of the globules; there were ſome of a pale yellow, ſome of a pale red like claret wine, ſome of the colour of a deep purple. The more robuſt and ſtrong the animal is, the ſtronger is the red colour of its blood; I have often obſerved theſe globules entirely to conceal the coats of the veins, and ſeemed to reſemble a chaplet of beads; no coat of any veſſel appearing (*c*). Lewenhoeck hath obſerved the ſame. This may convince one that their extremity, which ſeems naked, is not ſharp, but that their thickneſs is very conſiderable.

Exp. XII. *On many frogs*, July 11.

I have had many of theſe animals, and have found their veſſels entirely empty; this frequently happens in frogs eſpecially, when they have eat nothing, or have been confined: when they are thus confined, they fight and quarrel with one another, and I have ſeen ſome of them that in this manner had loſt a leg or an arm. In ſome frogs I have obſerved only one ſingle row of globules, filling only a ſmall part of the veſſel, ſometimes two or three rows, but not half ſufficient to fill the cavity.

(*c*) Exp. 124 is almoſt the ſame.

Exp. XIII. *On a frog*, July 25.

In this animal I ſaw the agreeable phænomenon of two columns of blood of different colours, which in the vein reſiſted each other. The blood which returned from the heart was of a fine deep purple colour, and that which came from the ſeat of the inteſtines was of a pale yellow.

Exp. XIV. *On a frog*, July 26.

I thought I ſaw the globules of blood to lengthen themſelves as they moved through the angles of the capillary veins; ſometimes they appeared of a bright ſhining colour, and ſometimes of a red colour; but 'tis a difficult thing to be poſitive with reſpect to this alteration of figure.

Exp. XV. *On a frog*, July 30.

I obſerved the ſame appearance as in experiment 14. but I cannot ſay any thing poſitive with reſpect to the alteration of figure.

Exp. XVI. *On a frog*, September 20.

The ſmall number of globules which were in the veins were yellowiſh; this often and almoſt always happens in the veins, whoſe blood a long time before had loſt its motion.

Exp. XVII. *On a frog*, September 23.

I obſerved between the two coats of the meſentery round globules, which ſeemed very ſpherical and which were yellow. I ſaw others which had changed their ſhape, and which appeared lengthened. There appeared ſome vermicular ones, as in Exper. 7. Bullæ of air diſperſed themſelves with the blood, between the two coats of the meſentery. In recollecting the examples wherein I have obſerved theſe bullæ of air, I am ſatisfied they only appear after a conſiderable wound of the veſſels, and that none of them are to be found when the veins have been carefully managed.

Exp. XVIII. *On a frog*, September 25.

The blood which collected itſelf together in the veins ſeemed ſomewhat oily; there appeared ſome ſtriæ in it, which extended themſelves its whole length. In this ſtate the globules did not loſe their ſhape. It is eaſy by bleeding to recover the blood again; for this operation ſeparates this maſs of globules, and makes the particles that are ſeparated become round.

Exp. XIX. *On a toad*, September 26.

There were between the membranes of the meſentery globules more apparent than in the veins. I carefully examined them, and I obſerved no difference in their different diameters; neither had I any reaſon to believe that one of their diameters were longer than another. The uniform red colour of theſe globules was not pale enough towards their extremities to make one ſuppoſe them ſharp, and the colour was too deep a red towards the center to deny them a conſiderable thickneſs; which probably may be equal to the other diameters.

Exp. XX. *On a toad*, September 30.

I obſerved, as in the 18th experiment, the blood at reſt in the veins, and collected into a maſs; it appeared like fixed oil, and therein I found longitudinal lines, but obſerved no polygonal net-work.

1. From theſe experiments I conclude, that the globules of animals that have cold blood are not flat, but that they are thick and very convex: and I believe we may without much heſitation ſuppoſe them ſpherical.

2. The blood of an animal that is languid (*d*), and that of an animal very young, and in its formation (*e*), is yellow; it becomes red when the animal is more formed and ſtronger, and its red colour doth not proceed only from the number of globules; they are often very red, even when they are obſerved to move one by one (*f*).

3. There is no air in the veſſels of an animal in health, neither is there any contained in the globules (*g*). The air which ſometimes appears

(*d*) Exp. 16, 19.

(*e*) Exp. 40.

(*f*) Exp. 3, 5, 8, 11, 12.

(*g*) Exp. 6, 7.

pears in the blood (*h*) is the effect of wounds in the veſſels (*i*).

4. The colour of the blood is ſo uncertain and changeable, that the blood of the ſelf-ſame vein hath been obſerved of two different colours at the ſame time (*k*).

5. There muſt be in the veſſels of animals that have cold blood ſome inviſible liquid; this is known by the continuance of motion in the globules, by the power of the heart as they follow one another in a row; ſome globules appearing at a diſtance from others (*l*). As there is no contraction in the veſſels of animals of this kind, this continued motion can only ariſe by means of ſome fluid which imparts the motion of the globule the neareſt to the heart to the globules which are more diſtant. A further proof of this is becauſe globules moving towards other globules contained in any blind cavity, are repelled from thence before they come into contact with them, probably by the power of this inviſible liquid which is between them, and the globules of this blind cavity. (*m*). I have obſerved this fluid to become viſible, and to create a ſort of miſt in wounded veſſels, through which miſt the red globules had but narrow paſſages; which proves they paſſed through ſome matter that made ſome reſiſtance to them.

(*h*) Exp. 3, 9, 17, 198, 214. (*i*) Exp. 17.

(*k*) Exp. 13. (*l*) Exp. 79, 83, 99, 122, 124, 128, 132, 138, 143, 234. (*m*) Exp. 93.

them (*n*). It is this lymphatic matter which diſchargeth itſelf from the veins when they are opened, and which forms a miſt round the orifice, and aſſiſts in cloſing the ſame (*o*). When this miſt is rubbed off, the hæmorrhage returns (*p*). As to the true ſtopple of wounded veſſels, it is a grume formed of a collection of ſome globules of red blood, which fills up the orifice, and ſometimes extends itſelf beyond it (*q*).

6. The blood becomes very often fixed and coagulated in the veſſels of a living animal (*r*); and theſe coagulated portions of blood may be reſolved and diſperſed (*s*).

SECTION II.

Various experiments concerning the colour of the arterial and venal blood.

Exp. XX. *On a little dog*, December 7, 1746.

THE blood of the pulmonary vein did not appear of a more lively colour than that of the pulmonary artery; I did not perceive in it any very viſible difference; I compared it with the blood which diſcharged itſelf out

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(*n*) Exp. 180, 183.

(*o*) Exp. 88, 153, 154, 157, 153, 167, 170, 176, 183, 189.

(*p*) Exp. 175, often repeated.

(*q*) Exp. 93, 160, 167, 170, 178, 183, 194.

(*r*) Exp. 6, 7, 60, 93, 155.

(*s*) Exp. 6, 7, 93.

out of a branch of the mammary artery, and it appeared to me much blacker.

Exp. XXI. *On a dog*, November, 1747.

I compared the blood of the pulmonary vein with that of the vena cava, but could find no difference therein, either with reſpect to its colour, or with reſpect to its conſiſtence, or inclination to coagulate.

Exp. XXII. *On a dog*, April 20, 1751.

I tied up the artery and crural vein of this animal, to try an experiment with reſpect to the circulation of the blood; afterwards I opened theſe two veſſels, the artery above the ligature, and the vein underneath it; and I confeſs that the blood of the artery ſeemed of a more agreeable lively colour than the blood of the vein, which ſeemed of a blackiſh colour.

Exp. XXIII. *On a kid*, May 12.

I compared the blood of the pulmonary vein with that of the pulmonary artery, the blood of the vein ſeemed to me of a more blackiſh complection than the blood of the veſſels of the lower belly, which I had wounded; and its difference from the blood of the pulmonary artery ſeemed to me very little.

Exp. XXIV. *On a frog*, Auguſt 16.

I touched with ſpirit of nitre the veins and arteries of the meſentery of this animal, the globules became of an earthy colour within the veſſels, and at the ſame time loſt their motion; but thoſe which retained their red colour retained alſo their motion.

EXP. XXV. *On frogs*, Auguſt 17.

I verified the ſame experiment; for ſpirit of nitre deprived the globules of blood of their ſhape through the membranes of the arteries; it changed them into a clay-coloured matter, and deprived them of their motion.

EXP. XXVI. *On a pregnant bitch*, Sept. 1.

I drew blood from the carotid, it preſently coagulated, and became a red maſs. I ſeparated the ſerum which divided from the grume, and mixed with it ſome well rectified ſpirit of wine; there appeared flakes, grumes, and a kind of membranous matter in this ſeroſity, and the red clot ſubſided. I mixed ſome vinegar to another part of this blood, which changed it into a diſagreeable blackiſh and earthy colour, and in the middle there was a grumous clod. With another part of the ſame blood, I mixed water, wherein I had diſſolved ſome nitre, and both the clod and alſo the reſt of the blood became of a higher colour; nothing ſeemed more beautiful than this colour: it equals the ſcarlet.

EXP. XXVII. *On a rabbit*, the ſame day.

I mixed with the blood of this animal, that as yet was fluid, ſome rectified ſpirit of wine;

it became changed into a kind of parenchymatous ſubſtance, like a kind of ſoft liver, whoſe laminæ and fibres connected each other. Vinegar made the blood ſeem black like ink; the clod that was in this blood reſolved of itſelf. A ſolution of nitre produced the ſame phænomena as in Exp. 26. At the end of twenty-four hours the blood wherein I had mixed a ſolution of nitre, became reſolved; that which had been mixed with vinegar became entirely fluid, with only a ſmall clod. The blood coagulated with ſpirit of wine, yet remained parenchymatous, but was not found harder.

Exp. XXVIII. *On a cat*, September 2.

I drew ſome blood from an artery, and it coagulated of itſelf; I mixed with it a ſolution of nitre, and it became again fluid and of a ſhining red colour: with vinegar the blood became black, having a clod of the ſame colour in its center; that which I had mixed with alcohol retained its parenchymatous coheſion at the end of twenty-four hours.

Exp. XXIX. *On a cat*, September 3.

The blood was black and coagulated; I mixed a ſolution of nitre to two portions of this blood; the one became entirely liquified, excepting one little clod; the other had a little more of the coagulum, and both appeared of a beautiful red; and the greater part was fluid.

Exp. XXX. *On a dog*, February 12, 1752.

M. Sproegel injected ſome vinegar into the jugular vein; the animal almoſt inſtantly expired, but the colour of its blood remained fine and unaltered (*t*).

Exp. XXXI. *On a dog*, February 5.

M. Sproegel killed it immediately, by injecting rectified ſpirit of wine into the jugular; the right ventricle of the heart was found filled with a parenchymatous blood in great clods (*u*).

Exp. XXXII. *On a dog*, March 7.

This phyſician alſo injected oil of tartar into the jugular of this animal, whereupon it immediately died, and the blood became ſo ſtrongly coagulated and fibrous that it reſembled the branches of the pulmonary artery (*x*).

Exp. XXXIII. *On a dog*, the ſame day.

We injected into the veins ſpirit of ſalt, and the blood became changed into black clots, but of a conſiſtence pretty ſoft (*y*).

Exp. XXXIV. *On human blood*, March 10.

A ſolution of nitre gave it the higheſt colour imaginable, one half of the blood retained its

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(*t*) Exp. 51. p. 79. (*u*) Exp. 48, 49, 50, of M. Sproegel. (*x*) Exp. 60, & 61, of M. Sproegel, page 88. (*y*) Exp. 57, & 58, of M. Sproegel, page 85.

its fluidity and the other half was changed into gelatinous laminæ.

Oil of tartar produced nearly the ſame effect, but the colour was not ſo fine.

The blood became coagulated and black with vinegar.

Spirit of wine produced a parenchyma, like that of the liver.

Exp. XXXV. *On a kid*, March 17.

I compared the blood of the two ventricles of the heart, but no difference appeared in it; the blood of the left ventricle was not more red than that of the right.

Exp. XXXVI. *On a dog*, March 18.

Spirit of wine camphorated was injected into the veins of this animal, whereupon the animal preſently died. The blood formed black clots, but it was not parenchymatous like that which was mixed with rectified ſpirit of wine.

Exp. XXXVII. *On a frog*, July 3, 1754.

The arterial blood of this animal and all others of this kind becomes coagulated and forms red clots, as well as the blood of animals that have warm blood: the ſame alſo happens to the venal blood.

Exp. XXXVIII. *On a frog*, July 24.

Repeated the ſame experiment as No. 37, with the ſame reſult.

Exp. XXXIX. *On a frog*, July 27.

The ſame reſult as in that where the blood was taken from the vein.

Exp. XL. *On chicks not batched*, Aug. 1755.

The blood of this animal is at firſt without colour in the veſſels of the chicken; at the end of the ſecond day it becomes yellow, in the two branches of the umbilical vein which form a circle round the amnios, and in the two branches of the umbilical arteries which go out of the belly of the animal, and which deſcend into the area of this circle. When theſe veſſels are filled with yellow blood, the branches which the venal circle ſends to the membrane of the yolk, are yet tranſparent; but the redneſs begins to ſhew itſelf in the umbilical trunks at their going out from the lower belly of the chick. The fourth day the blood of the veſſels of the membranes which ſurround the yolk is yet of this laſt colour; but the veſſels of the membrane which line the egg, the larger trunks of the yolk, and the veſſels of the fœtus, are red.

The experiments of this ſection, although they are not very new or ſingular, yet have their uſe with reſpect to ſome points in phyſiology; for, as example, they prove that the arterial blood hath not any apparent difference from the venal (*z*). The only experiment (*a*) where the colour of both hath not been the ſame, may be explained by the accidental variations of the colour of the blood in frogs, wherein two columns of blood in the ſame vein hath appeared of two different colours (*b*).

2. The acid of vegetables gives a very diſagreeable colour to the blood (*c*), and yet it is the moſt ſalutary. From thence we ſee, that we cannot conclude, that changes which happen in the blood proceed from the efficacy of medicines we have mixed with it.

3. Nitre imparts to the blood a ſhining red colour; at firſt it doth not prevent its coagulating (*d*), but afterwards it ſeems to reſolve it (*e*), contrary to the ſentiments of many practitioners.

4. Fixed alcalies, which are thought to reſolve the blood, ſeem rather to coagulate it (*f*).

5. The blood of animals that live without reſpiration is alſo equally ſubject to coagulate, as it is equally endowed with globules. Neither the red colour, nor the globules themſelves, nor the gelatinous nature of the blood, do at all therefore depend on the action of reſpiration (*g*).

SECT.

(*z*) Exp. 20, 21, 23, 25.

(*a*) Exp. 22.

(*b*) Exp. 13.

(*c*) Exp. 26, 27.

(*d*) Exp. 26, 27, 34.

(*e*) Exp. 27, 28, and in ſome meaſure Exp. 29.

(*f*) Exp. 32.

(*g*) Exp. 37, 38, 93.

SECTION III.

On the motion of the arterial blood, as it is obſerved with the naked eye.

EXP. XLI. *On a kid*, April 19, 1754.

The blood of a very little branch of the mammary, ſpurted one foot high.

EXP. XLII. *On a little dog*, December 7.

I eſtimated with more exactneſs the horizontal diſtance the blood ſprung from a ſmall branch of the mammary artery, which went out from between the ribs, and it appeared to be ſix feet ſix inches; which is much greater in all reſpects than it ſhould have been, according to the calculation of Keil, and the geometrical phyſicians.

EXP. XLIII. *On a dog*, December 16.

I obſerved again the diſtance the blood ſprang from an artery of the integuments, which came from between the intercoſtal muſcles, and it appeared to be three feet four inches.

EXP. XLIV. *On a rabbit*, Decem. 23, 1747.

The pulſation of the arteries, which is not always very viſible in living animals, was in the ſmall arteries of this animal viſible.

Exp. XLV. *On a dog*, January 12, 1750.

I obſerved in this dog, and almoſt in all animals which I have opened alive, the phænomenon often mentioned by Boerhaave; that is to ſay, the veſſels of the meſentery appeared ſmall and narrow on opening the lower belly, but they enlarge themſelves by degrees, in proportion as the blood becomes cold, and they become varicous.

Exp. XLVI. *On a ſheep*, March 6, 1751.

I ſaw the pulſations of an artery of the meſentery; it was violent in this animal, whoſe ſize exceeds that of thoſe we uſually ſubject to experiments. I traced it, and found it terminate on the membranes of an inteſtine. The artery formed a curve therein; in the firſt part of it, it was extended and enlarged, during the ſyſtole of the heart, and the part beyond the angle ſwelled not at all. The diameter of this artery being the laſt of thoſe whoſe pulſation was viſible, was found to be the ſixth part of a line. I ſaw the pulſation in other arteries of the ſame diameter; and the angle of their flexions were more acute. I opened this artery of the meſentery, and the blood was carried ſix feet high.

Exp. XLVII. *On a dog*, April 7.

I tied up the artery and vein of one of the fore legs, the artery ſwelled between the heart and the ligature, but in the vein the contrary happened. I opened the artery under the ligature, but it was flat and empty, and gave no blood: I opened it above the ligature, and the blood ſpurted out with violence; it was very prone to coagulate, and of a lively red colour. I obſerved the pulſation of the artery before it was opened, and obſerved it lengthened itſelf at each pulſation.

EXP. XLVIII. *On a dog*, April 20.

I tied up the crural artery of this animal; I ſaw it ſwell, and it became hard and rigid as a ſtick, and it lengthened itſelf at every pulſation: I opened it above the ligature, and the blood went from it with violenee: its ſpring was by turns ſtronger, and the difference of the height of its ſpring from the ſyſtole of the heart was very conſiderable (*h*).

EXP. XLIX. *On a dog*, in Auguſt.

I compared the ſpring of the blood from the pulmonary artery, with the force of that which went from the aorta; I opened the two arteries at the ſame time, the blood of the pulmonary artery was ſcarcely inferior in force to that of the aorta.

EXP.

(*h*) This is M. Remus's ſecond experiment; this phyſician repeats ſome others of this kind, which we have made jointly.

Exp. L. *On a young goat*, May 12.

I could not obſerve any pulſe in the arteries of this animal, neither could I obſerve it in a great many other ſubjects.

Exp. LI. *On a cat*, May 25.

I tied up the pulmonary artery of this animal, it ſwelled between the ligature and the right ventricle (*i*): I did the ſame alſo to the carotid, and it ceaſed ſwelling beyond the ligature, but was turgid towards the heart. But the difference of theſe two portions of the artery did not laſt long; for the ſuperior part of the carotid received as much blood by the anaſtomoſis's as was contained in the inferior part. I could not obſerve that this ligature made the animal heavy or drowſy.

Exp. LII. *On a cat*, May 27.

I alſo put on a ligature on the aorta under the reins; it ſwelled above the ligature and had a violent pulſation, and became ſmall and flat under the ligature. The animal loſt the uſe of its legs, and could not ſuſtain itſelf. It drew its legs after it with a kind of convulſion; perhaps, by the help of the pſoas and the internal iliac muſcles, the pulſation of the arteries of the meſentery, as alſo that of its branches; and alſo that of the ſmall capillary arteries was apparent, their ſupply being above the ligature. I afterwards opened the breaſt, and

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(*i*) Remus, Exp. 3. p. 8.

and put a ligature on the aorta; the animal became ſtupid, and loſt its ſenſes, although the heart beat with violence; the artery opened beyond the ligature, gave no blood.

Exp. LIII. *On a frog*, May 28.

I tied up the aorta under the origin of the large branches, at their going out of the heart. It ſwelled at every pulſation, and when it was opened it afforded blood with violence.

Exp. LIV. *On a frog*, July 22.

I report this experiment, although a microſcope is uſed therein, becauſe I would not ſeparate thoſe wherein ligatures are uſed. I tied up an artery of the meſentery with ſilk; the blood loſt its motion under the ligature, and alſo above it. The maſs of collected globules were at reſt, and did not ſwell the artery; the blood which came from the heart to this maſs did not at all ſeem to act on theſe immoveable globules, but returned and went into the neareſt branch; moreover, the blood that was at reſt above the ligature by degrees diſappeared, and left the artery empty from the branch to the place where the ligature was (*k*).

Exp.

(*k*) M. Remus reports an experiment ſomewhat like this, made on a *cat*, p. 4. and three others made on *frogs*, p. 43. I myſelf made theſe experiments, which I took no account of in my papers, becauſe I knew I could confide in the diligence and accuracy of my pupil. See Exp. 54. three times verified

Exp. LV. *On a cat*, September 2.

The pulſations of the ſmalleſt arteries of the meſentery and inteſtines were viſible.

Exp. LVI. *On a cat*, November 12.

I obſerved the pulſation of a ſmall artery of the inteſtines, it was crooked; and that part of it which was neareſt the heart, and which was lengthened by the impulſe of the blood, was extended beyond the ſecond part, and the angle which theſe two portions of the artery made, became more acute.

Exp. LVII. *On a little dog*, April 24, 1752.

I tied up an artery of the fore-leg, it ſwelled above the ligature, and had a violent pulſation, and it became always larger and longer at every freſh wave of blood from the heart.

Exp. LVIII. *On a dog*, Auguſt 10.

I again made the ſame experiment on the artery of the fore-leg, notwithſtanding which the animal could walk, though with pain. But the uſe of the leg was loſt after the nerve was tied up.

We find in the ſeries of theſe experiments numerous examples of the loſs of motion in the arterial blood, by uſing ligatures (*l*); and that the motion recovered itſelf by taking off

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(*l*) Exp. 192, 205, 207, 217, 220, 227, 228, 230.

the ligatures (*m*). Theſe experiments fully prove, that the principal cauſe of the motion of the blood is in the heart, and that the cauſe of the pulſe is carried on with the blood; and that it doth not conſiſt in the membranes, according to the opinion of the ancients.

The experiments of this ſection contain nothing particular or paradoxical: they all concur in eſtabliſhing the truth already received, concerning the circulation of the blood. The 54th Experiment, three times verified, ſhew, that arteries which are obſtructed neither ſwell nor dilate themſelves; which muſt happen, according to the common theory of inflammations. Inſtead of forcing the membranes of the veſſels, the blood that enters the obſtructed arteries by any cauſe whatever, returns from thence, and enters the firſt branches of the ſame trunk, which are not obſtructed. From hence is the great dilatation of the arteries of the pelvis, and of the femoral arteries, after the umbilical arteries are tied up. The ſame phænomenon happens in aneuriſms; for the blood doth not dilate them, but turns its courſe from them to the veſſels that are free (*n*).

(*m*) Exp. 207, 87.

(*n*) Exp. 93, 188.

SECTION IV.

Experiments on the motion of the arterial blood, made with the aſſiſtance of a microſcope.

EXP. LIX. *On a little fiſh*, Aug. 15, 1743.

THIS experiment did not ſucceed, neither ſhould I have taken any notice of it here, had it not been my firſt attempt. I made uſe of an extreme convex glaſs, when the ſolar rays were very ſtrong. I obſerved in the tail of the fiſh two parallel veſſels, one brought the blood from the head to the tail, and the other carried it in the contrary direction. There were many branches of communication between theſe two veſſels: I ſaw the rows of globules as they moved, but I was not able to diſtinguiſh the membranes of the veſſels.

EXP. LX. *On a frog*, May 5. 1747.

I diſcovered the meſentery, which I extended on hooks, in which I obſerved the arteries and veins; many rows of globules of theſe two claſſes moved with rapidity in their ſeveral veſſels without any diſcontinuance. The blood ceaſed its motion, although the heart was in motion; and the blood became fixed, and formed grumous maſſes.

Exp. LXI. *On a frog*, May 24.

I made uſe of the ſtrongeſt and moſt convex glaſs; I obſerved a retrograde direction in the motion of the arterial and venal blood. The motion continued in the arteries after it was loſt in the veins; I ſaw the blood accelerate its velocity, and afterwards turn back and move in its natural direction. The arteries appeared pale, but the veins of a lively red colour, and both larger and more numerous than the arteries.

Exp. LXII. *On a little fiſh*, May 31.

This experiment ſucceeded better than the preceding ones; there were the whole length of the little bones of the tail veſſels in pairs, an artery and vein which accompanied each other. The motion of the blood of the one was reverſe to that of the other; they were ſo contiguous the one to the other, that they might have been taken for one canal. At the extremity of the tail the artery was reflected, and formed its contiguous vein. There were alſo middle branches between an artery and a vein, parallel to each other; they went out from one, and entered into the other under different angles. As death drew near, the blood ceaſed its motion in the trunks, but moved ſwiftly in the ſmall branches.

Exp. LXIII. *On a little fiſh*, June 10.

There are four little bones parallel to each other in the tail of this animal, like unto thoſe little bony thorns near the mouth. To the whole length of theſe four little bones, there are fixed four pair of veſſels, an artery and a vein to each bone, the one contiguous to the other. The blood moves ſwiftly through theſe veſſels, but its velocity is greater in the arteries. Between theſe large veſſels, which are parallel among themſelves, there are many branches only of one or two globules diameter: theſe alſo ramify and form plexus's and anaſtomoſis's between the arteries and the contiguous veins: often the angle they make in entring the vein, is more acute than that which they formed at their going out of the artery.

I ſaw alſo very diſtinctly in what manner the arteries form themſelves into veins, by reflecting themſelves at ſome diſtance from the end of the tail; and then become of many globules diameter. I alſo at that time obſerved that the globules of blood did not move by a rolling motion, but that they moved in a ſtrait line, by ſwimming in an inviſible liquid (*n*).

Exp. LXIV. *On a little fiſh*, June 26.

I made uſe at this time of a glaſs leſs convex; I ſaw the arteries and veins were parallel, the

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(*n*) Exp. 93, 188.

the blood had a ſwift motion, and its velocity diminiſhed as death approached, when the blood became in a perfect ſtate of reſt. There were at leaſt ſix rows of globules in one artery; I ſaw veſſels of only one globule diameter, and in which only one ſingle globule moved. I alſo obſerved, that the globules do not roll on their axis.

Exp. LXV. *On a little fiſh*, July 15.

I obſerved again the tail of this little animal; I took notice the blood moved with as great a velocity in the ſmall branches as in the great trunks. I obſerved that the blood almoſt loſt its motion, and moved backwards and forwards alternately. After this irregularity the globules became regular, both with reſpect to their velocity and direction of motion. I obſerved nevertheleſs the blood to ſtop at the extremity of the tail, although the blood nearer the heart yet continued its motion. The artery may be diſtinguiſhed from the vein, both by the direction of the blood, and by the velocity, which is much leſs in the vein than in the artery. I was not able to diſtinguiſh in the artery the acceleration which I expected from the motion of the heart.

Exp. LXVI *On a frog*, July 16.

The arterial blood continued its motion although the blood of the veins had loſt theirs. But a retardation of motion gained by degrees on the arteries, at which time I obſerved ſome confuſion and pertubation in the blood, compoſed of a balancing dodging motion. The artery *a* divided at *d* and formed two branches *c d* and *b d*. The natural motion of the blood was from *a* to *d* where it divided, and part of the globules moved to *b* and the other part to *c* but in the animal which I had then under examination, the blood turned back by the branch *b d* and returned to *d*: from thence the globules of this branch for a moment repelled thoſe of the trunk *a d*, and moved in a retrograde motion to *a*: the next moment they deſcended from *d* to *e* ſo that theſe globules had a motion compounded of the natural and retrogade. A ſmall time after the blood of the branch *c d* prevailing againſt that of the branch *b d*, it returned from *c* to *d*, and from this point of diviſion it repelled the blood of the trunk *a b*, and returned towards *a*: a part even of this blood returned from *d* into the branch *b d*. Thus the blood moved alternately in contrary directions. The ſtrongeſt current prevailed over the weaker, and repelled it, and the next moment in its turn it gave way. Sometimes alſo the blood of the trunk recovered its natural motion, being propelled by the force of the heart, and the blood returned from *a* to *d*; and from thence to *b* and *c*; it ſeemed to me, that this natural motion returned by means of ſome irritation. In the veſſels of this animal, and in general in the arteries and veins of all fiſh, and of all animals which have cold blood, and have fallen under my examination. I have not obſerved the leaſt appearance of contraction, and the blood ſeemed to move in the veſſels as in immoveable glaſs tubes (*o*).

Exp. LXVII. *On two frogs*, July 17.

The arterial blood had loſt its motion although the blood in the veins retained ſome little motion. I confeſs I had taken away the heart of the animal; the arterial blood moved with ſo great rapidity, that I could not obſerve any acceleration at the time of the contracting of the heart. But when the frog had loſt a great part of its ſtrength, I perceived the velocity of the blood to increaſe at every pulſation; and it was at this time that the blood recovered its natural motion, and ceaſed to move retrograde. The membranes of the veſſels were covered with black ramifying particles, ſomewhat reſembling darts, a phænomenon I have often obſerved, but they do not impede the motion of the blood. I ſaw ſome ſingle globules between the membranes of the meſentery: I could not obſerve any dilatation or contraction in the arteries.

Exp. LXVIII. *On a little fiſh*, July 19.

I enjoyed for two hours the following engaging phænomenon. I obſerved two arteries faſtened to two little bones of the tail of this little

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(*o*) M. Remus hath obſerved the ſame, p. 43.

little animal; I obſerved a plexus of veſſels between the two arteries, going from different directions of the veſſels, entering them again by turning like a hook: the veſſels forming this plexus, admit only one globule at a time; (*p*) when the animal becomes weak, the blood ſtops; afterwards it turns its courſe, and moves in its natural direction for ſome minutes. I have obſerved this direction of motion to take place in the ſmall veſſels at a time when the blood returned back again into the trunks: and I have obſerved the motion of the blood conſiderably ſwift in the branches, at a time when the blood was almoſt at reſt, and reſembled oil in the large veſſels.

Exp. LXIX. *On a frog*, July 20.

An artery having been wounded by accident, a quantity of blood ran between the laminæ of the meſentery, where it connected itſelf into a maſs, which afterwards by degrees diſperſed. The motion of the blood in the veſſels became by degrees confuſed, but this change was a little ſlower in the arteries than in the veins. Yet this diſorder prevailed in the arteries; the blood moved back towards the heart, and afterwards fell again into its natural direction. I ſaw the blood return

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(*p*) This plexus, of which I have alſo ſpoken in Exp. 59, 62, 63, ſeemed to me to be a venal plexus, like that of the meſentery in frogs. I confeſs I have not purſued theſe experiments, and after this I have chiefly made uſe of frogs.

from two branches into the common trunk, and conſequently to move retrograde towards the heart during the diaſtole of this organ, and afterwards it returned from the trunk into the branches in the following ſyſtole. This happened many times for a conſiderable time: the parieties of the arteries are white, thick and firm without any contraction or dilatation; the impulſe of the wave from the heart, acts not on them. The action of the globules in their motion againſt the parieties of the arteries is extremely weak; ſome time after the blood began to have a dodging motion coming and going; and I obſerved this alternate motion for full three hours. All being now without motion, I put another portion of the meſentery under the glaſs, when the blood was therein in its free motion; the ſize of the whole artery was double that of its light. The two branches of a trunk are, as in man, larger than the trunk itſelf. I irritated a nerve, but the effect was not very apparent.

Exp. LXX. *On a frog*, July 21.

I lacerated the meſentery by careleſſneſs; this is an accident we muſt guard againſt, becauſe it diſorders the experiment.

The motion of the globules on the parieties of the arteries is without the leaſt effort or force. The parieties were once larger than the light of the artery, and were perfectly immoveable.

veable. The motion of the venal blood continued longer than that of the arterial.

Exp. LXXI. *On a frog*, July 22.

I could ſee very eaſily for a conſiderable time the ſwift motion of the blood in the arteries, and afterwards the pulſe which was made with an acceleration of the blood, and without any dilatation of the artery. A vein paſſed before an artery, whoſe dilatation had it been ever ſo ſmall muſt have affected it by ſome elevation. But neither the vein nor the artery underwent any change of ſituation. The diameter of the membranes of the artery was equal to that of the light. The part of the meſentery I had under view, in three hours time became rigid; therefore I changed it, and found the blood continued its motion in the arteries, but in the veins it was entirely at reſt. The arteries became entirely empty, and the meſentery dry, yet the heart continued to beat (*q*).

Exp. LXXII. *On two frogs*, July 27.

All motion ceaſed in the capillary plexus, whoſe veins only ſuffered one ſingle globule to paſs them; all motion alſo was loſt in the venal trunks preſently after, but a motion yet remained in the artery for ſome time. I obſerved an artery, *a d b* which gave in a branch *d c*. The velocity of the blood being leſſened, I obſerved the blood to ſtop under the riſe of

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(*q*) Remus, Exper. 3. p. 43.

the branch, in the part of the trunk *b d*; wherein I ſaw the blood had an oſcillatory motion, though the current *a d c* continued regular, and moved freely from the trunk *a d* into the branch *d c*. It appeared in this experiment, that the velocity was greater in the branch than in the trunk itſelf.

Exp. LXXIII. *On a frog*, July 29.

I obſerved at this time no motion at all in the arteries of the meſentery, although in the veins of one and two globules diameter the motion yet continued. I had under the glaſs an artery which had four branches; two of theſe branches made an angle with the trunk, of near ninety degrees, the two other branches were almoſt directly continued from their trunk. I obſerved whether the reſult of this phænomenon would juſtify our theory, and whether the motion preſerved itſelf longer in the branches ariſing under an acute angle, than in thoſe under a right angle. This proved true, for the firſt preſerved their natural motion, when that of the latter, after ſome diminution and acceleration of motion, became entirely loſt (*r*). I obſerved again that the arteries are not at all dilated by the heart, and that they do not in the leaſt elevate any vein lying under them. After the ſpace of two hours I ſaw diſtinctly the acceleration and increaſed motion, which every freſh wave coming from the

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(*r*) Remus. p. 40.

the heart created. The blood by degrees forſook the arteries, and there remained only in their cavity a ſmall number of globules. In four hours after the beginning of the experiment the blood moved with difficulty in the arteries, and its accelerations were very apparent at every ſyſtole of the heart. At the expiration of ſix hours the major part of the arteries were found empty; I took care the meſentery ſhould not grow dry by moiſtening it from time to time. I obſerved yet an artery wherein the blood had a dodging motion; it went backward and forward alternately. The next day all became dry, and the arteries entirely empty.

Exp. LXXIV. *On a frog*, July 30.

The arteries of the meſentery were as ſmall as thread, and empty at the beginning of the experiment. I found, that the female frogs having their ovary very turgid, are not ſo proper for experiments as the male.

Exp. LXXV. *On two frogs*, Auguſt 16.

The arteries did not at all contract themſelves, although I touched them with ſpirit of nitre; I obſerved then and one hundred times ſince, that the arteries are ſometimes found full, ſometimes only one half full, and ſometimes entirely empty.

Exp. LXXVI. *On many frogs.*

I verified the 75th experiment, that the arteries have not any power of contraction, and that ſpirit of nitre doth not contract them.

Exp. LXXVII. *On a frog*, Auguſt 30.

The ſelf-ſame artery was obſerved to be almoſt empty in one part and full in another; the membranes of the empty part exceeded the light, which remained for the conveyance of the globules.

Exp. LXXVIII. *On two frogs*, Aug. 30. and 31.

I emptied the veins by repeated bleedings, yet the blood continued its motion in the arteries; there appeared but a ſmall quantity of blood, even before theſe operations: and it is a common thing to find in frogs that have been confined a day or two without a ſupply of food, this deficiency of blood.

Exp. LXXIX. *On a frog*, September 3.

Neither this animal nor any of the others which I have examined had any contraction in the arteries. The globules of the ſmall veſſels follow each other in a row at a great diſtance, with a uniform velocity. Some inviſible fluid ſeems to form and conduct this chain of globules, by which means they are continued in their motion.

Exp. LXXX. *On a frog*, September 21.

I obſerved in an artery of the meſentery a true aneuriſm; the blood fell into it globule by globule from the internal trunk: the motion of the blood was loſt in the aneuriſm, but in going out of its cavity it recovered its motion, as alſo it did when it entered that part of the artery whoſe diameter was not dilated.

Exp. LXXXI. *On four frogs*, May 14, 1754.

The arterial blood had a ſwift motion, but the venal blood had loſt its motion; when the motion of the arterial blood was abated, the alternate acceleration of the blood which every contraction of the heart created with a new velocity, was perceptible. There were but few globules in the artery; for it was almoſt empty, and they moved therein one by one. Another artery dilated itſelf, and formed a kind of irregular deformed aneuriſm, under which it became narrower. The arteries of theſe animals certainly have no power of contraction; the thickneſs of their membranes makes them appear pale, and the veins which are generally more full and not ſo thick may be diſtinguiſhed by their red colour.

Exp. LXXXII. *On a frog*, May 30.

The blood moved ſwiftly in an artery of the meſentery, but the blood in an adjacent vein had loſt its motion; the diviſion of the arteries doth not ſeem to impede the blood in its motion through them. I could not obſerve any difference between the velocity of the blood in the branches and that of the trunks.

In this artery were formed two true aneuriſms filled with a great many globules; they were ſeparated and divided by the ſmall ſize of ſome parts of the artery, and which admitted only a ſmall number of theſe globules.

The power of the heart in accelerating the blood at its ſyſtole, was very obſervable.

The venal blood had loſt its motion, but that of the arteries had a dodging motion, by moving from the ſeat of the inteſtines, and afterwards changing its direction it moved towards the heart: its velocity diminiſhed by degrees in ſome branches, and entirely ceaſed; although a motion was continued in others. At laſt, all the arteries of the meſentery were without motion.

Exp. LXXXIII. *On a frog*, May 31.

I obſerved again in the arteries of the meſentery the blood was in ſo ſmall a quantity, that the globules followed each other at a great diſtance; from which I again conclude, that ſome inviſible fluid muſt continue their connection.

Exp. LXXXIV. *On two frogs*, June 5.

The blood moved both in the arteries and veins a long time in a natural and uniform manner. In the arteries the blood went forwards by jerks, which were alternately accelerated. In general, the velocity of the arterial blood was greater than the velocity of that in the veins, whoſe blood became entirely at reſt, although its motion yet continued in the arteries. The coats of the arteries are thick and immoveable. In the ſecond frog there was no blood in the arteries at the beginning of the experiment. I had no ſucceſs by arteriotomy in that which had blood.

Exp. LXXXV. *On a frog*, June 26.

The arterial blood is not accelerated by the impulſe of the heart, while its motion is briſk; but when its motion is abated the acceleration becomes very perceptible: I obſerved when the animal was become weak the aorta furniſhed no more blood to the meſentery. The blood of theſe arteries ceaſed their motion, and the globules which only occupied a part of the cavity of the artery remained at reſt. The pulſe may be obſerved in the animal when it is ſtrong and vigorous, the whole extent of the lungs, and in the brachial artery, but not in the deſcending aorta; and in the arteries before-mentioned the pulſe abates by degrees. As the animal becomes more languid, the blood of the heart comes but to the beginning of the aorta, and none is diſtributed to the more diſtant parts.

Exp. LXXXVI. *On a frog*, July 3.

The lungs are furniſhed in their circumference with hexagonal cells, ſome whereof are larger than others; whereof the ſmaller ones more reſemble thoſe of the human lungs, and ſurround every large veſicle. The internal ſurface of the lungs is a cavity, which is continued with all the hexagonal veſicles. The arteries ramify between the veſicles. The animal is able, *ad libitum*, to inflate and ſwell up all its lungs, which it often doth even in the midſt of pain; although frogs make no noiſe in this ſtate. When it ſwells the lungs, all the arteries of this viſcus lengthen themſelves: the next moment the animal diſcharges its lungs of the air, which upon the arteries fold themſelves again over each other.

An artery that is empty is not found at all contracted; its cavity remains the ſame, even though there are no globules to fill it.

Exp. LXXXVII. *On a frog*, July 19.

I recovered the motion of the arterial blood by bleeding; the reſult was, an oſcillation in an artery which had two branches: one of theſe branches had a retrograde motion; the blood moved back towards the heart, and coming to the diviſion it divided itſelf, one current entered the other branch of the artery, and was carried briſkly to the inteſtines, according to its natural direction. The other turned back by the common trunk of the two branches, and returned from the heart until it had loſt its motion.

Exp. LXXXVIII. *On a frog*, July 24.

I obſerved the motion of the blood in an artery, and the vein that accompanied it; the motion was ſo violent in the artery that the eye could not ſcarcely follow it. The weight of the blood had no power over this velocity, neither did it all diminiſh when it moved in a direction contrary thereto.

A pricked artery having degenerated into an aneuriſm, and the motion of the blood eſtabliſhing itſelf through this tumour, I could very diſtinctly perceive that this motion began by a ſingle row of globules, which was brought by the artery, and paſſed into the aneuriſm. Preſently after three or four other red rows of globules paſſed through a kind of thickiſh ſubſtance that was in the cavity of the aneuriſm; after theſe the current of the blood became reſtored in all reſpects as natural.

Exp. LXXXIX. *On two frogs*, the ſame day.

I ſeparated the artery of the meſentery; yet it preſerved its diameter as if no alteration had been made.

Exp. XC. *On a frog*, July 26.

I obſerved many aneuriſms in one artery; alſo I obſerved the tumours were oval and of many globules diameter: above and below the aneuriſm I obſerved ſmall threads of blood in the artery. I ſaw very diſtinctly the globules that were diſperſed between the laminæ of the meſentery to re-unite in the cellular ſubſtance that ſurrounds the arteries.

This portion of the meſentery being dry, I applied another; herein I obſerved the circulation of the blood was as in a natural ſtate.

Exp. XCI. *On a frog*, the ſame day.

The arteries often appear extremely pale at the beginning of the experiment, at which time their cavity ſeemed to be ſmall and the thread of the globules very thin. By degrees the circulation recovered itſelf, and their light increaſed, and many rows of globules in a ſwift motion filled the arteries. This favourable change I obſerved this day, without any aſſiſtance by bleeding.

I obſerved again that in the motion of the arterial blood there appeared neither any acceleration or jerks, while the animal remained ſtrong; but when it becomes weakened an acceleration, ariſing from the motion of the heart, becomes perceptible.

Exp. XCII. *On a frog*, July 30.

I obſerved for ſome time a pretty large artery; when firſt I began to obſerve it its coats were twice the diameter of its light; or if you pleaſe its light made only one third of the diameter of the whole artery, and the coats the remainder. But this proportion is not conſtant.

The motion of the blood becoming conſiderably ſtrong, in proportion as the veſſels became more full of this vital fluid, the light increaſed, and the thickneſs of the coats diminiſhed; at the end of the experiment it made only one fourth of the diameter of the light. I alſo obſerved an aneuriſm, it was nearly oval, its light many times exceeded the thickneſs of its membranes. The blood paſſed ſlowly thro' the aneuriſm.

I waited full two hours to obſerve when the motion of the arterial blood would diminiſh, but its velocity was preſerved, and continued in the arteries all that time: at laſt an inciſion in the artery diminiſhed the velocity. The blood in the artery moved ſlowly, and that in the aneuriſm entirely ceaſed its motion; it repelled the freſh wave of blood which came from the heart.

The meſenteric arteries are formed nearly like thoſe of the large inteſtines in man; each trunk divides into two branches, extending themſelves the whole length of the inteſtine, and which communicate with each other, furniſhing their branches to the bowels. It is ſtrange that I have not been able to obſerve any branch of an artery in the venal plexus, ramifying on the void ſpaces of the meſentery: there does not appear to ariſe any one arterial branch in this ſpace.

Exp. XCIII. *On a frog*, Auguſt 6.

After having opened a vein, I diſcovered in this animal a part of the meſentery wherein I found an artery whoſe blood in the trunk *a d c* had no motion at all; but in the branch *d b*, which went off at right angles from this trunk, the blood preſerved its natural motion. By degrees the motion abated in part of the trunk *d c*, which was under the riſe of the branch; but above this part the blood was entirely at reſt. We obſerved the blood of the inferior part of the trunk *d c*, and that of the branch *d b*, to dodge in its motion for ſome time; and that of the branch at laſt overcame the other, and entered again into the inferior part of the trunk, and moved from thence to the inteſtines. It repelled at the ſame time the ſmall number of globules of the ſuperior part of the trunk *a d*, and by degrees the motion became eſtabliſhed the blood of the branch *d b* united with the blood of the trunk *a d*, in order to deſcend by the part of the trunk *d c*. But this partial diſorder did not always remain; for the blood recovered its natural motion, it went from *a* to be diſtributed into the branches *d b* and *d c*, in which it moved ſwiftly and with conſtancy. Before this natural direction of the blood took place, there deſcended from the point *a* ſome globules connected and glewed to each other, and which the impulſe from the heart put into motion by forcing them forward. This obſtacle being removed, the natural direction of the blood recovered itſelf. I obſerved little ſtrugglings at times; for the blood turned back from *b d* and from *c d* againſt *a*, and repelled the blood which came from the heart; but theſe irregularities laſted but a ſmall time; for the natural direction recovered itſelf, and took place preſently after.

Having ſo often obſerved aneuriſms even in their formation, when I had the animal under examination, I had a deſire of forming ſome by art. I thought I perceived that theſe aneuriſms formed themſelves when ever any part of the arteries became weakened. I ſeparated therefore a certain portion of the artery from the cellular membrane which connected it to the meſentery; I ſhook it the better to deſtroy its connection, taking care not to wound it: preſently after this I obſerved an aneuriſm was formed; it appeared an oblong tumor much larger than the artery from whence it aroſe, and which gave a paſſage to the blood which moved in it but ſlowly. I cut one of theſe aneuriſms in the part that was the moſt diſtant from the heart; from this wound not one globule iſſued: it ſeemed to me, that a ſemicircular membrane terminated the aneuriſm on that ſide: a grume of blood filled up the wound. The blood intirely ceaſed its motion in this blind cavity, formed by ſeparating the aneuriſm from the inferior part of the artery. I obſerved the irregular and dodging motions of the blood reſulting from hence: the blood which came from the heart was reſiſted by that of the aneuriſm, and it was repelled by it even to the origin of the neareſt adjoining branch; a moment after this wave of blood had its natural motion, and propelled the blood of the aneuriſm towards the bottom of this cavity, but not one drop was diſcharged from it. This ſtruggle between the blood of the aneuriſm and that from the heart continued a long time: It ſeemed to me that ſome inviſible fluid filled the ſuperior part of the aneuriſm, and that the blood from the heart was repelled by it before it arrived at this cavity. The globules of the aneuriſm had the advantage by degrees, they ſo powerfully repelled the blood which came from the heart by the trunk of the artery, that this trunk entirely became empty. The aneuriſm on the contrary became filled with blood, but without dilating itſelf. The blood of the trunk diſcharged itſelf into the next adjoining branch whereinto it ruſhed very ſwiftly; for I evidently perceived that the blood moved in this branch with a greater velocity, than in the larger trunk from which it had paſſed. I took away the trunk of this artery with a pair of nippers, and it reſembled an irregular cone, at whoſe extremity not one globule of blood was diſcharged. This blind cavity and a branch ariſing from the trunk that was taken away were by degrees filled with globules.

Exp. XCIV. *On a frog*, the ſame day.

Having by accident wounded the meſentery there aroſe two aneuriſms in the artery, the blood freely paſſed through them; I very eaſily diſtinguiſhed the velocity with which it paſſed in the narrow part of the artery, and the ſlower motion it had within the aneuriſms.

Exp. XCV. *On a frog*, September 20.

The motion of the blood being irregular in the artery, its trunk *a b* had two branches *b c* and *b d*; the blood came from the heart in *a*, and preſently after it moved retrograde towards the heart: there was an oppoſition which aroſe between the branch *b c* and *b d*, ſometimes the blood came from *c* to *b*, and at the diviſion of the trunk, it deſcended from thence into the branch *b d*, and ſometimes the blood of the branch *b d* returned from *d* into *b* and from thence deſcended towards *c*; a moment after the blood moved regularly, and went from *a* to paſs to *b* and from thence into *c* and *d* with a double velocity, which dilated the arteries and diminiſhed the thickneſs of their coats.

Exp. XCVI. *On a frog*, September 27.

I created an aneuriſm in one of the arteries of the meſentery, by ſeparating the artery

from

from its membrances and ſhaking it. All that part of the artery which I had thus treated formed an elliptic aneuriſm; the artery preſerved its diameter above the aneuriſm, it was there narrower. The aneuriſm became filled with blood.

Exp. XCVII. *On a frog*, September 27.

The motion of the blood appeared very diſtinct although this animal had been two days confined and without food. I created an aneuriſm in the ſame manner as in the preceeding experiments; this aneuriſm was oval and not very large, and became full of blood which ran into a coagulum.

Exp. XCVIII. *On a frog*, September 28.

I ſeparated the artery from its connection with the meſentery, and ſhook it, by which I created two true aneuriſms.

Exp. XCIX. *On a frog*, September 29.

The aorta of this animal having been cut I obſerved globules moving in a row, and one by one in the artery of the meſentery.

Exp. C. *On a frog*, September 30.

I ſeparated the artery from its cellular connections, but no blood being contained in the artery, no aneuriſm enſued.

Exp. CI. *On a toad, whoſe belly was of an orange colour.*

In this experiment the aneuriſm ſucceeded as common, and the blood ſtopped therein.

Exp. CII. *On a toad*, October 1.

I ſaw the circulation of the blood on the membranes ſuſtaining the canals for the ſemen. The pulmonary artery hath a manifeſt pulſation in all its extent; as alſo the meſenteric trunk, but the pulſe is not perceptible in its branches. I endeavoured to calculate the velocity of the blood circulating in the veſſels of the lungs; but could not with any certainty: I obſerved it ſcarce moved with as great a velocity as that of the meſentery. The arteries ramify in the ſpaces between the veſicles and lobes of this viſcus.

I draw many conſequences from theſe experiments, and

1. The blood in the ſmall veſſels is not ſo much retarded as is generally ſuppoſed; ſince it appears to circulate with as great a velocity as in the trunks (*a*): and there are examples wherein the motion in the larger veſſels hath been ſuppreſſed, notwithſtanding the motion in the ſmall arteries continued (*b*). I ſhall relate when I come to the veins, other experiments which will confirm this opinion.

(*a*) Exp. 65, 68, 72, 82. (*b*) Exp. 62.

2. The blood globules do not roll on their axis (*c*); they regularly ſwim in the veſſels in ſtrait lines; their action on the arteries (*d*), or againſt any reſiſtance in their diviſions (*e*) is without the leaſt violence; this perhaps may be the reaſon why veſſels that are tied up or obſtructed are not dilated.

3. The remarkable oſcillations of the blood (*f*) often re-ſtabliſh its natural motion (*f*).

4. The arteries have not the leaſt power of contracting, and the blood moves through the veſſels of this claſs as it would through glaſs tubes (*g*). I do not deny that the membranes of an artery when cut contract themſelves, and form under an aneuriſm that is ſeparated from its trunk, a kind of blind cavity (*h*).

5. The acceleration of the blood, ariſing from the heart is not perceptible while the animal remains ſtrong and in vigour, but it is very apparent, as the animal becomes weak (*i*). The artery is not dilated by the motion of the heart (*k*): I ſpeak with reſpect to the arteries of the meſentery; for the large trunks that are near the heart do dilate themſelves. This

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(*c*) Exp. 63, 64, and all I have made agree herein. (*d*) Exp. 69, 79. (*e*) Exp. 82. (*f*) Exp. 66, 69, 72, 82, 87, 95. (*g*) Exp. 66, 67, 69, 70, 75, 76, 79, 81, 84, 86, 93, 180, 199, 201, &c. (*h*) Exp. 93. 181. (*i*) Exp. 67, 81, 84, 91, 126, 163, 173, 189, (*k*) Exp. 67, 69, 71, 73, 79, 138, 143, &c.

This is a new proof of the ſuperior rigidity of the branches, in compariſon to the trunks.

6. The arteries are ſometimes found empty (*l*) and ſometimes half empty (*m*) at the beginning of the experiments; and this happens from wounds and bleeding. Sometimes the globules fill but a very ſmall part of the cavity of the arteries, and ſometimes there are none. It is not therefore true when it is ſaid, that the arteries are always full in a living animal, or that they contract in proportion as they loſe their blood.

7. The effect of the angles in diminiſhing the velocity of the blood is not certain. The blood hath been obſerved to circulate with a greater velocity in branches ariſing under ſmall angles (*n*); and indeed the contrary hath been obſerved (*o*).

8. But the effect of the dilatation and of the increaſed light of the arteries is certain. Both theſe cauſes diminiſh the velocity of the blood in a ſmall branch, as alſo in a ſmall narrow trunk the blood moves with a greater velocity (*p*). The ſame happens in an artery under an aneuriſm (*q*). The motion diminiſheth (*r*), and quite ſtops (*s*), and becomes grumous in the aneuriſms.

9. The

(*l*) Exp. 71, 73, 74, 75, 78, 81, 84, 86, 172, 182, 218, 219, 225, 234, &c. (*m*) Exp. 81, 85, 226.

(*n*) Exp. 73. (*o*) Exp. 72, 93. (*p*) Exp. 93. compare Exp. 126. (*q*) Exp. 94. (*r*) Exp. 92, 93, 94. (*s*) Exp. 80, 92, 93, 96, 101, 187.

9. The proportion of the thickneſs of the coats of the arteries to the magnitude of their light is uncertain; and theſe coats are capable of compreſſion. In an animal that is weakened they have a much larger diameter than the light of the arteries (*t*); but when the circulation becomes ſtrong and vigorous their light increaſeth, and the diameter of the membranes diminiſh; but the diameter of the whole artery undergoes no alteration (*u*). It happens ſometimes that the light exceeds by far the thickneſs of the coats. I do not remember that this variation, with reſpect to the thickneſs of the membranes of the arteries, hath been taken notice of.

10. We ought not to deny the exiſtence of theſe true aneuriſms (*x*), examples whereof are ſo frequently obſerved in the human aorta. It is proved by experiment (*y*), that aneuriſms of this claſs may be created by weakening a part of the artery, and by detatching it from its cellular membrane, or by wounding the artery (*y*). * Is it not poſſible that abceſſes which weaken the cellular membrane, may give riſe to aneuriſms?

11. Experiment doth not confirm the particular velocity of the blood paſſing through the lungs.

SECTION

(*t*) Exp. 70, 76, 92. (*u*) Exp. 71, 92, 95, 183.

(*x*) Exp. 80, 81, 82, 88, 89, 92, 93. (*y*) Exp. 93, 94, 96, 97, 98, 101, 230. (*y*) * Exp. 180.

(*z*) Exp. 102.

SECTION V.

Experiments on the motion of the venal blood, made without the uſe of a microſcope.

Exp. CIII. *On a rabbit*, June 25, 1731.

THIS is the ſame experiment which I have before related in ſpeaking of the arteries (*a*); that is to ſay, the veins of the meſentery were ſmall and narrow when I opened the lower belly, they began to ſwell and became full of blood, and alſo became thick and varicous after the meſentery had been expoſed to the air ſome time.

Exp. CIV. *On a cat*, November, 24, 1750.

I opened the vena cava; the blood guſhed out with a conſiderable ſpring, and with ſuch a force that one would not have expected from a vein.

Exp. CV. *On a dog*, April, 6, 1751.

I tied up the vein of a fore leg (*b*), it ſwelled under the ligature; but above it became flat and empty, and very thin; I opened it in this place and it gave no blood, but it afforded it abundantly when I had opened it under the ligature towards the paw, though without any ſpurt or ſpring.

Exp.

(*a*) Exp. 45.

(*b*) Exp. 2. of Remus, and the following belong to this.

Exp. CVI. *On a dog*, April 20.

I tied up the vein of one of the hindmoſt legs, it ſwelled between the foot and the ligature, and gave blood abundantly on being opened on that ſide; it flowed without any intermiſſion, but not with any ſpurting or ſpring.

Exp. CVII. *On a kid*, May 12.

I tied up the great vein of the meſentery, where upon it apparently ſwelled (*c*) between the ligature and the inteſtine, but it neither became empty nor thinner between the ligature and the liver. The meſenteric branches do not diſcharge their blood towards the vena porta when they are tied up.

Exp. CVIII. *On a kid*, May 29.

I tied up the vena cava inferior above the diaphragm; this is eaſily done in animals, which have this portion of the cava very long, it very much ſwelled towards the diaphragm and was filled with blood: I tied up the trunk of the veſſels of the porta at its entrance into the liver, and above the inſertion of the ſplenic vein, whereupon the veins of the meſentery became extremely large.

Exp. CIX. *On a cat*, May 27.

I tied up the vein in the lower belly, but the ſwelling above the ligature did not ſubſide, for

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(*c*) M. Remus reports the ſame experiments made on a cat, p. 4.

for it being under the inſertion of the renal veſſels. The azygos, the lumbar veins, and the ſpermatic, were not prevented from ſupplying it with blood.

Exp. CX. *On a frog*, May 29.

I tied up the abdominal vena cava, it ſwelled under the ligature, but the ſwelling ſubſided, and the vein became flat above the ligature towards the liver.

Exp. CXI. *On a frog*, July 22.

I tied up one of the trunks of the meſenteric veins (*d*) and examined with a microſcope the effects of this ligature. The blood that ought to have paſſed again to the heart by this vein that was tied up, turned its courſe from this vein, and paſſed into the adjacent branches, as if it had been compelled to take that courſe by the globules of blood whoſe motion was hindered in the vein that was tied up. The blood was without any motion above the ligature in the branch that was tied up: a vein entered the trunk above that part of the veſſel that was tied up, which was filled with blood that was without any motion: it avoided this blood and returned contrary to the common motion of circulation, and entered an adjoining branch, by which it returned by the inteſtines,

and

(*d*) Remus, p. 44. theſe two experiments had the ſame reſult.

and continued its courſe by a vein which communicated with it.

Exp. CXII. *On a frog*, September 28.

I tied up the meſenteric vein, it ſwelled a little between the inteſtine and the ligature (*e*).

Exp. CXIII. *On a dog*, February 22, 1752.

I tied up the two jugular veins of the animal; they ſwelled above the ligature, but the animal was not thereby affected with any heavineſs or ſtupidity.

I obſerved that a dog, whoſe jugulars had been tied up after injections, was well; for I met him in the ſtreet, and he ſeemed not at all diſcompoſed by the ligature that was then remaining on the part.

Exp. CXIV. *On a dog*, October 8.

I tied up the external jugular, it ſwelled above the wound, towards the head, and became empty towards the heart. The head did not ſwell, neither did any ſalivation or ſpitting enſue, and indeed I have not in other ſubjects hitherto obſerved theſe ſymptoms.

1. The major part of theſe experiments ſerve only to confirm thoſe of Harvey, and the laws of circulation diſcovered by this great man. We have obſerved that many veins do not ſwell under the ligature from which we from

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(*e*) Remus reports an experim of the like nature made on a cat, p. 10.

have drawn objections againſt this new diſcovery: but theſe objections may be eaſily anſwered by comparing the experiment 108, with the experiments 107, 109, and 112. when the common trunk of all the veins of the meſentery is tied up, the blood finding no paſſage for its return to the heart, ſwells all the branches that are under the ligature. But when only one particular vein of the meſentery is tied up or ſome vein which receives large branches above the ligature, the ſwelling does not ſubſide in that place by reaſon of its communications that furniſh it with blood.

Experiment 111 (*f*), with reſpect to the veins, confirms what we have ſaid concerning the arteries, ligatures, and conſequently obſtructions, do not ſwell the veſſels which are obſtructed, for the blood avoids them and finds other paſſages whereby it returns to the heart.

(*f*) Exper. 12.

SECTION. VI.

Experiments on the motion of the venal blood, to be made only with the aſſiſtance of a microſcope.

Exp. CXV. *On a frog*, May 7, 1747.

IT did not appear to me that the venal blood moved with a leſs velocity than the arterial, even at a time when I obſerved it retrograde, it retained its uſual velocity.

Exp. CXVI. *On a frog*, May 27, 1751.

The veins were extremely red, and the globules were accumulated and collected together in great numbers at a time when the arterial blood preſerved a very free circulation.

Exp. CXVII. *On a frog*, July 9.

The motion of the venal blood was very free, but yet its velocity was leſs than that of the arteries. A ſmall time after the venal blood loſt its motion, and ſoon after it recovered it again; it ſeemed to me that this recovery of motion happened from ſome irritating cauſe. Before it became in a perfect ſtate of reſt: the venal blood had a dodging motion moving backwards and forwards.

Exp. CXVIII. *On a little fiſh*, July 15.

It is certain that the blood in the veins moves with a great velocity, although this velocity is inferior to that of the arterial blood.

Exp. CXIX. *On a frog*, July 16.

The venal blood loſt its motion ſooner than that of the arteries, and a quantity of it began to ſtagnate in the veins. I obſerved near a large vein of the meſentery, ſome ſmall tranſparent veſſels wherein the globules moved with a great velocity, although they were but few in number and at a great diſtance from each other. Theſe veſſels formed a plexus, and their blood had as ſwift a motion as that of the veins of many globules diameter: theſe globules were true red globules, both with reſpect to their ſize and colour, and they returned into the veins, and mixed themſelves with the reſt of the blood without any diſtinction; the blood in the arteries continued its motion, although that in the veins was entirely at reſt.

Exp. CXX. *On a frog*, July 17.

The venal blood was ſwift in its motion, in which it ſeemed to equal the arterial, but at other times we eaſily diſtinguiſhed the ſuperior velocity of the arterial blood. I ſaw again the plexus of veins of only one globule diameter, ſituated beyond the ordinary veins of the meſentery. The veins undergo no ſtate or degree of dilation or contraction, neither have they any pulſation.

Exp. CXXI. *On a little fiſh*, July 19.

I found in the tail the veins which accompanied the arteries, and ran parallel with them, but they were not very apparent, alſo I ſaw other veins placed between theſe trunks, which follow the little bones. The motion of the blood is almoſt as ſwift in the veins as in the arteries; ſometimes the motion of the blood in the large veins is ſwifter, at other times no difference is obſervable.

Exp. CXXII. *On a frog*, June 20.

The venal plexus ſituate between the great branches of the meſentery appeared again, the globules moved in them with great velocity, although they followed each other in rows at ſome diſtance. The motion of the blood was diſcompoſed in the veins, although its motion in the arteries appeared regular, and this irregularity of motion appeared in the trunks, although the motion was regular in the ſmall veſſels. In the veins we cannot perceive any change of motion made in the blood by the impulſe of the heart. By degrees the blood loſt its motion, both in the veins and venal plexus, and preſently after in the arteries: therefore I put another portion of the meſentery under the glaſs, wherein I obſerved it continued its motion, which was not yet in the leaſt abated.

Exp. CXXIII. *On a frog*, July 21.

The blood had no motion in the arteries, although it preſerved its motion in the veins. it had a dodging motion; there was a maſs of globules connected and faſtened together; the blood took up a retrogade motion and moved to this maſs; it returned from thence as if it was repelled by it, and moved in its natural direction.

Exp. CXXIV. *On a frog*, July 22.

I obſerved a long while the motion of the blood in an artery and vein that were conſiderably large. The motion was almoſt as ſwift in the vein as in the artery. It was alſo extremely briſk in the ſmall veſſels of the venal plexus, wherein the globules moved in a ſingle row, and at a conſiderable diſtance from each other; the globules moving from the extremities of the veins formed a half circle, and reſembled a chaplet of beads: for the membrane of the veins is ſo fine as not to be viſible; but it is not thus in the arteries, whoſe membranes are thicker. I began to be ſatisfied that the plexus of ſmall veſſels is a plexus of veins only. The diameter of the veins appeared in general double to that of the parallel arteries. After having employed full three hours in this obſervation, I ſubjected to my examination another portion of the meſentery, and I obſerved that the arterial blood was yet in motion, but the venal blood was at reſt; the meſentery being dry, the veins remained full of blood.

Exp. CXXV. *On two frogs*, July 27.

Two veins had an anaſtomoſis by a ſhort branch which united them. I with ſatisfaction obſerved in them an extraordinary irregularity in the motion of their blood, one of theſe veins I call *a b f*, and the other *e c d* and the veins which united them *b c*, it communicated with them in the points *b* and *c*. I ſaw the blood move from *a* by *b c* into *d*; I ſaw it come from *e* by *c b* into *a*, and again from *f* by *b c* into *e*, and from *d* by *c b* into *a*; this was a compound of the direct and retrogade motion. In the other frog I ſaw again the venal plexus compoſed of capillary veins of one globule diameter, and of ſome other veins which admitted two or three globules to paſs them. The blood moved in theſe veſſels with a great velocity, which continued although the blood in ſome of the trunks was intirely at reſt: by degrees, nevertheleſs the blood loſt its motion, both in the venal plexus, as in the reſt of the veins, in which the motion had been continued, but the motion of the arterial blood yet continued. I obſerved alſo and with a convincing ſatisfaction, as to this matter, that the blood moved with a great velocity, in the large veins and alſo in the ſmall ones, although a little more ſlowly than in the arteries. As to the globules I could not obſerve they had the leaſt friction againſt the parieties of the veins.

Exp. CXXVI. *On a frog*, July 29.

The motion of the blood of the veins in the center of the meſentery appeared ſwift, even the blood of the veins of one or two globules diameter, had a briſk motion, at the time when the blood of the neighbouring arteries was at reſt. An hour after I had began the experiment, the motion of the venal blood appeared ſwifter than that of the arterial. In a vein that was reflected I obſerved a globule of blood paſſed the cavity of the vein at the flection, without the leaſt difficulty or violence. Four hours after the beginning of the experiment the venal blood vigorouſly continued its motion, even in the ſmall branches, at the time when the motion of the arterial was diminiſhed; and we could perceive very diſtinctly therein the impulſes from the motion of the heart. Two veins by their re-union formed one trunk: I obſerved that the blood had a greater velocity in the trunk than in the branches of which it was formed. After ſix hours the blood in the great vein of the meſentery continued its motion, but its diameter was irregular, and it was narrower towards the heart: the motion of the blood was very rapid in the narrow part of the vein. The veſſels of one globule diameter diſappeared; at nine at night the blood yet returned in the veins of the ſtomach and meſentery. There are no valves in theſe veſſels. The next day no motion was perceptible, and the veins were filled with blood.

Exp. CXXVII. *On a frog*, Auguſt 17.

The globules moving in a row in the venal plexus, tho' at a diſtance from each other, yet move ſwiftly. I thought I ſaw an artery of two globules diameter inſert itſelf into a trunk of a vein; but after a great many experiments I believe it was a vein.

Exp. CXXVIII. *On a frog*, Auguſt 23, 1752.

The blood hath a briſk motion in the veins but not ſo briſk as in the arteries, and the difference in the velocity of their motion ſeemed to me to be in the inverſe proportion of the diameters of the veſſels of theſe two claſſes. The motion of the blood in the capillary veſſels of one ſingle globule diameter is conſiderably quick, even when theſe globules are at ſome diſtance from each other. The motion of the blood in theſe ſmall veſſels ceaſed before that in the trunks.

Exp. CXXIX. *On four frogs*, May 18, 1754.

I obſerved the venal blood to recover its velocity after it had been diminiſhed, and which had degenerated into a balancing and librating motion. I ſaw the blood repaſs from the trunk into the branch, and return from the branch to the trunk, and oppoſe the motion of that of the trunk. The motion of the blood in the trunk ceaſed, yet that of the capillary veins continued.

Exp. CXXX. *On a frog*, May 30.

I obſerved no alternate jerks in the motion of the venal blood, neither in this experiment nor many others.

Exp. CXXXI. *On a frog*, May 31.

I obſerved at the diviſion of two branches what friction the blood had on the parieties, at the flexions of theſe branches, when it moved back towards the inteſtines; and I found that the motion was performed at theſe places extremely eaſy. I obſerved varices on the vein of a larger diameter than the reſt of the veins.

Exp. CXXXII. *On two frogs*, June 5.

The motion of the venal blood was ſwift, but yet not ſo ſwift as the arterial. The motion is without any jerks or acceleration: this motion is ſwift, even in the veins of one or two globules diameter, as is alſo the motion of the blood in the venal plexus of the meſentery, which hath been often before taken notice of; the globules of theſe ſmall veſſels form one ſingle row, and the globules are diſtant from one another, about the diſtance of the diameter of one globule, and ſometimes of two. In this and the greateſt part of the experiments, theſe veſſels are the firſt that loſe their motion, even when the blood moves freely in the trunks. Two veins were united by one branch, which was extended from one to communicate with the other: the two oppoſite columns of blood which came by the two veins, endeavoured to enter this branch of communication. A reſiſtance enſued, but at laſt the largeſt, and, wherein the motion of the blood had the greater velocity, prevailed over the other. I obſerved empty ſpaces in the vein, and in a great part of it, only a few diſperſed globules were found in a ſmall part of its cavity, they were without any motion; there appeared neither in this nor any other experiments any contraction in the membranes of the veins, which were extremely thin.

Exp. CXXXIII. *On a frog*, June 26.

The motion of the venal blood hardly appeared to me to be more rapid, than that of the globules which were extravaſated, and which moved between the two membranes of the meſentery, the impulſe from the heart created no jerks in the motion of the blood.

Exp. CXXXIV. *On a frog*, July 24.

I obſerved the motion of an artery and vein which accompanied each other; the blood of the firſt had an extreme rapid motion, and the motion in the ſecond was but moderate. The globules in the middle of the vein, and moving in its axis, have a much greater velocity than thoſe that are near the ſides. I ſaw an oſcillatory motion in a venal trunk conſiderably large, one moment the blood returned towards the inteſtines, the next moment it was carried with rapidity to the heart. In the ſame trunk the blood at the ſame time had contrary directions; one portion of the blood turned back towards the inteſtines, and the other proceeded in its natural courſe towards the heart.

Exp. CXXXV. *On a frog*, July 25.

I tore a vein of the meſentery with a pair of nippers, I folded up the extremity of it that was towards the heart. I bent and folded up the end, and waited the effect, no blood iſſued from the vein that was tore, although its natural direction was towards the wound, it ſeemed repelled by the extremity of the vein, and returned by a librating motion towards the inteſtines.

Exp. CXXXVI. *On a frog*, the ſame day.

I had at my leiſure obſerved the rapid motion of the arterial and venal blood, whoſe motion was leſs violent than the firſt. I once again tore another vein in order to convince me if there was any ſolidity and certain truth in the preceeding experiment. It appeared to me there was not; for the blood iſſued from the end of the vein that was tore, whether its extremity was ſtrait or folded back:

I could perceive no contraction in the vein. The blood flowed a conſiderable time.

Exp. CXXXVII. *On a frog*, July 26.

I along time diligently obſerved the motion of the venal blood. I obſerved two parallel trunks, *a b c* and *d e f*, a branch *b c* joined them in *b c*, making an acute angle with *a b c* and an obtuſe one with *d e f*. The blood in theſe veins had a motion in all directions poſſible. I ſaw it move in a retrograde motion from *a* by *b* into *c e* and *f*. The blood of the other venal trunk alſo had two different retrograde motions; ſometimes it moved from *d* by *e* into *f*, and ſometimes it moved from *d* by *e* into *b*, and from thence to *c*. I ſaw it alſo move in its natural direction, and to paſs from *c* by *b* into *a*, and from *f* by *e* into *d*. I ſaw alſo ſome motions that were a compound of the natural and retrograde motion; for I obſerved it to move and come from *a* by *b a e* and *f*, and from *d* by *e* into *b* and *a*. In all theſe oſcillations there often is a reſiſtance and ſtruggling between theſe oppoſite columns of blood, created by the weight and velocity of the globules, which ſeem as it were to repell each other. I obſerved the blood of a ſmall vein, but it was not a capillary one, to paſs into a large venal trunk from which it was repelled, whereupon it entered again this ſmall vein, from whence it ſhould have been diſcharged.

The portion of the meſentery under the glaſs being dry, I took another part, in which I found that the motion of both the arterial and venal blood was yet continued and free. This part ſeemed to me to reſemble a gangrene on the part.

I ſuſpected that the cauſe of theſe retrograde motions, which were ſo frequent in the veins proceeded from ſome hurt in the inteſtines. The hooks often wound ſome veſſel therein, whereby a derivation is produced on the part.

Exp. CXXXVIII. *On a frog*, July 30.

I had this animal full three hours under obſervation; I diſcovered an artery and vein of the meſentery, and alſo a plexus of many capillary veins, ſituate between theſe two trunks. It ſeemed to me that this plexus is not formed of venal trunks, but only of capillary branches, going off from one trunk to enter another.

The motion of the blood in the venal trunk being abatad, I obſerved I thought convulſive jerks gave it ſome degree of acceleration at times: I am certain that the blood of a vein of one two or three globules diameter had a ſwifter motion than that of the venal trunk, above named.

The globules of theſe ſmall veſſels are at ſome diſtance from each other, in which ſpace I think ſome inviſible fluid muſt be contained.

A ſmall vein was extended before the trunk of an artery: it was not at all elevated by its pulſation, and its globules had a free motion.

Exp. CXXXIX. *On a frog*, Auguſt 6.

The oſcillatory motion, the retrograde motion, and the natural motion of the blood ſucceeded each other in the arteries for a long time, the blood in the contiguous veins moved with leſs velocity; but yet the motion was in its natural direction: it returned even with a conſiderable velocity from the ſmall veſſels of the venal plexus, into the trunks of the veins. This motion of the blood continued in the veins full eight hours, and even continued untill ten at night.

Exp. CXL. *On a frog*, Auguſt 30.

The arteries were ſmall and all empty; in the veins there was but little blood, and it moved but ſlowly.

Exp. CXLI. *On a frog*, September 22.

The blood in two veins of the meſentery had a motion compounded of the natural and retrograde motions. The blood returned by one of the veins, it paſſed into the other, and afterwards deſcended in its natural direction from the inteſtines.

Exp. CXLII. *On a frog*, September 23.

The oſcillatory motion of the venal blood continued after the heart had been taken away. The vein *a b* divided itſelf to form the branches *b c* and *b d*. One moment the blood of the trunk had a retrograde motion, and came from the point *a* to the extremities *c* and *d*; its weight forced it this way. But the next moment, the natural motion took place and the blood returned from *c* and from *d* by *b*, in order to move from *a*, and to return to the heart againſt its own gravity. There came alſo globules from one of the branches *b d*, and from the extremity *d* to the point of diviſion *b*: they paſſed into the other branch towards *c*, againſt their own weight. In the ſame manner alſo globules came from the branch *c b* to the point of diviſion *b*, and moved to the other branch *b d*.

Exp. CXLIII. *On a frog*, September 25.

I obſerved the veins and arteries of the meſentery a long time, many ſmall ones re-united and made one. The motion of the blood in the branches ſometimes had one direction and ſometimes another; and the blood was moved towards oppoſite points. There were again obſerved ſmall capillary veins of one globule diameter, ariſing from a vein, and which capillary veins communicated with another vein, after they had formed a plexus. The globules moved ſwiftly through thoſe ſmall veſſels, even although their row and chain was not continued, and the globules were at ſome diſtance from each other.

Exp. CXLIV. *On a frog*, September 28.

The venal plexus was very fine and the velocity of the globules therein was very great.

The blood in the veins was not at reſt altho' half empty, until a long time after I had taken away the two great arteries. A very ſmall vein lay before an artery; but this vicinity to the artery created no alteration in the vein, its blood having a free motion.

Exp. CXLV. *On a frog*, the ſame day.

The portion of the meſentery, under examination was very beautiful; I obſerved therein large arteries, many venal trunks, and the uſual capillary venal plexus, whoſe veſſels were of about one globule diameter. I obſerved very diſtinctly the current of a large vein to repel one coming from a ſmall branch to enter the vein, but was repelled by this ſtronger current. This perhaps may be the reaſon why the capillary veſſels do not communicate with venal trunks, and why they form by their reunion large veins, that they may be able to bring back and convey their blood into larger veins.

Exp. CXLVI. *On a frog*, September 29.

In this animal and alſo in that of Exp. 230, the blood continued in a librating motion in the veins for twelve or thirteen minutes after the deſtroying the two great arteries. I ſeparated a vein from the meſentery, and created a varix, in the ſame manner as I produced aneuriſms.

Exp. CXLVII. *On a toad*, October 1.

The plexus of the ſmall veins of the meſentery is very fine in theſe animals, and much more agreeable than in frogs; they appear like polygon maſhes.

1. I conclude from theſe experiments that the venal blood hath a leſs degree of velocity in its motion (*a*), and alſo (*b*) leſs conſtancy in its motion than the arterial blood, but yet experiments prove, that the motion of the venal blood is very ſwift (*c*); and there are examples wherein the motion hath been as briſk and as conſtant (*d*) as that of the arteries.

2. I obſerved again that the motion of the blood was not ſlower in the branches than it was in the venal trunks (*e*); and that in the capillary plexus it moves with a great velocity, and ſometimes with more conſtancy than it hath in the large veſſels (*f*). Generally the blood hath a ſwifter motion in the trunks than in the branches (*g*). But all that hath been ſaid concerning theſe enormous retardations and diminutions of the motion of the blood in the arteries and capillary veins is entirely fabulous; ſince the velocity of the blood in the

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(*a*) Exp. 116, 117, 118, 119, 120, 124, 125, 128, 132, 134. (*b*) Exp. 72, 119, 122, 125, &c. (*c*) Exp. 115, 120, 126. (*d*) Exp. 123, 126, 140. (*e*) Exp. 119, 122, 124, 125, 127, 128, 132, 138, 143, 144. (*f*) Exp. 122, 125, 126, 152, 233. (*g*) Exp. 126.

veins of only one ſingle diameter appears ſo conſtant and conſiderable.

3. The librating balancing motion of the blood takes place in the veins as well as in the arteries (*h*), and it often alſo terminates in the re-eſtabliſhing of the natural motion of the blood (*i*).

4. The blood hath directions in its motion very inconſtant and different in the veins, which communicate with each other, and the anaſtomoſis's appear to contribute to the preſervation of the motion of the blood; ſince in them the motion is continued the longeſt time, even after the blood had loſt all its motion elſewhere (*k*).

5. The veins, like the arteries, have neither dilatation or conſtriction (*l*).

6. The impulſe of the heart is not perceptible in the veins (*m*).

7. The motion of the blood is a little ſtronger in the axis of the veſſels (*n*).

8. Whether the flexures and curves of the veſſels retard the motion of the blood muſt be decided by other experiments; there are experiments which ſeem to eſtabliſh it (*o*), and alſo ſome the contrary (*p*).

(*h*) Exp. 117, 123, 124, 129, 132, 134, 137, 142, 143, 145, 224, 225, 226, 230, 234. (*i*) Exp. 123, 129, 66, 83, 95. (*k*) Thirty-ſix minutes after the extirpation of the heart, Exp. 230. (*l*) Exp. 120, 132, 136. (*m*) Exp. 122, 130, 132, 133. (*n*) Exp. 134. I have related the ſame in other experiments.
(*o*) Exp. 135, 182. (*p*) Exp. 136.

9. The return of the blood of a ſmall vein, by being repelled by the current from a trunk, into which it could not paſs, ſhews the advantage of the azygos, and alſo of the thoracic duct (*q*).

10. Varices may be produced, by depriving the veins of their cellular connections (*r*).

SECTION VII.

Experiments on the effects of bleeding, with reſpect to the motion of the blood: and on acceleration, derivation, and revulſion.

EXP. CXLVIII. *On a ſheep*, March 6, 1751.

THE blood of an artery of the meſentery of this animal ſprang ſix feet high: I opened a ſecond artery near the firſt, but it ſprang not above one foot from either orifice.

EXP. CXLIX. *On a bitch*, June 3.

She was pregnant: I opened the jugular vein, whereupon ſhe died by the loſs of blood: but the young which I extracted by the cæſarean operation and their umbilical veſſels were not at all the leſs furniſhed with blood.

EXP. CL. *On a frog*, Auguſt 30.

I took away the heart of this animal, and the blood ran through the arteries and veins of the meſentery, towards this large wound.

EXP.

(*q*) Exp. 137, 144. (*r*) Exp. 145, 180.

Exp. CLI. *On a frog*, the ſame day.

I opened a vein and afterwards an artery, in this animal, in the meſentery (*s*). In the two experiments the blood was ſwiftly carried towards the wound; it moved thereto even againſt the natural order of the circulation, and turning back again precipitated itſelf into the wound. By this it appeared there was a derivation, and that the blood ruſheth into the veſſels communicating with the vein that is opened. Alſo by this there appeared to be a revulſion, at leaſt with reſpect to the heart, and that this viſcus, oppreſſed by the blood, may be diſcharged of it by bleeding. The blood, which appears grumous and coagulated, reſembling oil, ſeparates itſelf by bleeding, and the globules both recover their form and natural motion, and move ſwiftly towards the wound.

Exp. CLII. *On a frog*, May 5.

I twice opened a vein of the meſentery: the blood guſhed from the wound extremely ſwift, like a torrent, with a velocity abating by degrees. The blood haſtens to the wounded vein, both in its natural direction and alſo in a retrograde one.

Exp. CLIII. *On a frog*, September 3.

I verified on this animal only, ſeven times ſucceſſively the experiment, I conſidered and obſerved

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(*s*) Remus reports ſeven experiments like this, p. 59, 60, and 61.

obſerved the great ſwiftneſs the venal blood had before bleeding, and I always found, both in this experiment and all others, that bleeding increaſeth this velocity, how great ſoever it may be before this operation. The blood throws itſelf towards the wound, as well from the ſeat of the heart, as from the veins communicating with that which is opened. Theſe two oppoſite columns of blood ſtrike on each other at the entrance of the orifice, and alternately repel each other. After ſome little time the wound cloſeth, and the blood recovers its natural motion in the vein, on its becoming perfectly healed. I alſo opened an artery, the blood haſtened into the orifice from the heart, and alſo it returned thereto from the inteſtines. This motion was indeed more rapid than that in the veins. But in the arteries the torrent ceaſed ſome time after, and the blood recovered its natural motion in the artery, which had been opened and which became entirely healed up. I wondered at the great velocity the blood hath in diſcharging itſelf from the wounds of the veſſels, and alſo I wondered at the ſtrength of this animal; for the blood preſerved its natural motion in the venal plexus of the meſentery, notwithſtanding ſeven times bleeding. The blood which diſcharged itſelf from the vein by a wound, diſtributed itſelf between the membranes of the meſentery.

Exp. CLIV. *On a frog*, September 14.

I opened a vein of the meſentery, whereupon the blood haſtened to the orifice, by all the veins communicating with the vein that is wounded, and in all directions that could carry it thither. Two oppoſite columns met at the orifice, from whence they are vehemently diſcharged of their blood, which diſperſeth itſelf in the form of waves ſomewhat like clouds between the laminæ of the meſentery. One of the columns came from the heart, and the other from the inteſtines.

As the blood was yet running from the orifice of the vein, it ſeemed to me that the motion of the arterial blood loſt its velocity. Preſently after it ceaſed to move; the motion abated even in the orifice, the globules were but ſlowly diſcharged from it, and a little after none at all. The vein being cloſed, the column of blood which returned from the heart and which was diſcharged from the wound, gave way to the column, which moved in its natural direction in returning from the inteſtines, and this column re-eſtabliſhed its motion in the vein.

Having again bled this animal, the blood came to the wound only in its natural direction: towards the heart the venal trunk was now empty.

Exp. CLIV. *On a frog*, the ſame day.

I verified three times the ſame experiment, and always with the ſame ſucceſs. The blood always moved towards the wound with aſtoniſhing rapidity: it was carried thereto from the ſeat of the heart, as alſo from the inteſtines; it ſeemed to me that the retrograde column had a greater velocity than that which returned in its natural direction towards the heart. The blood goes out of the vein in a whirling motion; the two oppoſite currents reſiſt each other, and often the retrograde column overcomes that which is in its natural direction. By this ſtruggle a ſtrait line is formed, which ſeparates the two columns, and leads directly into the wound: the wound by degrees cloſeth; a cloud or miſt of red filaments appear round the orifice: it is more pale in the circumference, and of a deeper red in the centre (*t*): the blood recovers its natural motion, and returns into the heart by the vein which had been opened. Sometimes its motion, is diſcontinued, and it falls back towards the inteſtines. I three times made this experiment on this animal. Although theblood in the vein is entirely at reſt, there ariſeth an extreme velocity by bleeding, both in the vein that is opened, and in all the adjacent branches. I opened an artery, and the blood returned from the inteſtines towards the wound. Although there were but very few red globules in the

arteries,

(*t*) M. Remus deſcribes this miſt, p. 60, 61.

arteries, which were almoſt empty; yet theſe globules moved even in a retrograde direction into the wound.

Exp. CLV. *On a frog*, September 15.

I verified the ſame experiments with the ſame ſucceſs; the blood in the vein had no motion; but after the inciſion was made it went from thence with a greater velocity than in an animal in health. It is carried into the wound by two oppoſite currents, which ſtrike againſt each other, and which equally guſh into the wound: at other times one of theſe torrents prevails over the other, and repells the other back from the wound, entirely hindering it from entering the orifice.

I obſerved again, at this time, that favourable miſt which cloſeth the wounds of the veſſels, and ſtops the bleeding. The ſame in a manner happens in the arteries; the blood throws itſelf violently into the wound, and with an aſtoniſhing velocity in a retrograde direction. But this rapidity abates, as it doth in the veins, and the wounds of the arteries cloſe up, and the natural direction of the blood takes place.

The blood was at reſt in the veins when I opened one: the blood recovered its motion by this bleeding, and the globules which were gathered together, and ſeemed to form a coagulum, began to ſeparate, and re-aſſumed their natural ſhape. A collection of ſix, eight, or ten globules at once detached themſelves, and moving towards the orifice diſcharged themſelves from it.

Exp. CLVI. *On a frog*, September 20.

I opened many times an artery and a vein in this animal; when the artery was opened it gave blood from the part that was towards the heart: as for the inferior part, at the inciſion the blood therein had no motion, neither did any move from that part into the wound. By degrees the inciſion cloſed up, but the circulation did not recover itſelf in the artery. I opened, and more than once, a vein: in all which experiments the blood was carried from the heart, and from the ſmall branches of the vein to the wound with a conſiderable velocity, and in contrary and oppoſite currents; all the neighbouring veins ſent their blood to the orifice. This wound at laſt cloſed up as uſual. Another bleeding recovered the languiſhing motion of the blood. The motion began to ceaſe in the part of the vein that was the neareſt the heart.

There was in a vein a large ſemi-lunar wound, and there remained entire only a ſmall part, which was above the wound, and which equalled only a ſmall part of whole light of the vein. When the current of blood had ceaſed to diſtribute itſelf by the wound, the circulation was carried on by this ſmall part that was entire, and no blood was carried through the wound.

I was willing to obſerve, if the blood would have any increaſed velocity in the arteries, at the time the blood is running from the vein: and it ſeemed to me, that the velocity diminiſhed more than increaſed.

Exp. CLVII. *On a frog*, September 21.

The blood moves to the wound by all the veins which communicate with that which is wounded. The column which returns from the ſeat of the heart ſtrikes againſt that which comes from the inteſtines, and the former prevails and almoſt always repels the other; becauſe it is generally larger, and the velocity of its blood is at leaſt equal to that of the other. By degrees the blood loſeth its motion, and a miſt is formed round the orifice of the vein.

Exp. CLVIII. *On a frog*, September 21.

M. Sproegel made this frog ſwallow ten grains of opium; the blood in the veins of the meſentery was at reſt, when I opened one of them; but the motion recovered itſelf therein, and the blood haſtened towards the orifice, both from the heart and from the inteſtines; the blood alſo was carried thither from all the veins which had any communication with the vein that was wounded, and its velocity was ſurpriſing, Exp. CLIX. *On a frog*, September 29.

The heart had not any motion, and the blood was at reſt in the veſſels of the meſentery when I opened a vein. The blood violently diſcharged itſelf from the orifice, whereto it was brought, both from the heart and from the inteſtines, but longer from the heart. The velocity of the blood recovered itſelf in all the veins which had any communication with the vein that was opened.

Exp. CLX. *On a frog*, September 29.

The blood had loſt all its motion in the veins of the meſentery, when I opened this vein. When the vein was opened there enſued an extreme ſwift motion, as well in the vein that was opened as in the two veins that communicated with it. I ſaw better than before in what manner the wound cloſeth: a collection of red globules remaining in the wound, cloſed up the orifice I had made with the lancet.

Exp. CLXI. *On a frog*, Auguſt 10, 1752.

I verified the preceeding experiment.

Exp. CLXII. *On two frogs*, Auguſt 16.

This experiment proved the ſame as before. The blood had a retrograde motion in the vein when I opened it, but it was propelled into the wound, both in the retrograde as well as in its natural direction; and the velocity of the blood recovered itſelf, both in the vein that was opened, as well as in all thoſe which communicated with it. I could not diſtinguiſh whether the velocity of the blood at that time ncreaſed in the adjacent arteries.

EXP. CLXIII. *On two frogs*, Auguſt 23.

The opening of a vein much accelerated the motion of the venal blood; the blood of the artery that accompanied it had loſt its motion; but this bleeding reſtored it.

At another time, the velocity of the arterial blood was conſiderably abated, and at every motion of the heart the acceleration of the blood was perceptible. I opened a vein, and it ſeemed to me that this bleeding had accelerated the motion of the blood in the adjacent artery. A red miſt as uſual cloſed up the wound.

After an hour's examination, finding that the arterial as well as venal blood was at reſt, I repeated bleeding, whereupon the motion recovered itſelf in both the arteries and veins, with a conſiderable velocity. In an hour after the meſentery became entirely dry, which put an end to all further examination.

EXP. CLXIV. *On four frogs*, May 14, 1754.

I opened a large vein, whereby the motion of the blood both in the veins and arteries was accelerated; and the blood haſtened towards the opening of the veſſel in its natural direction, as alſo in a retrograde one.

Exp. CLXV. *On a frog*, May 20.

The blood flowed with a conſiderable velocity into the vein when I opened it. The blood ran out ſo precipitately and ſo copiouſly from the wound, that all the veſſels became empty and dry, and the wound cloſed not.

Exp. CLXVI. *On a frog*, May 31.

I accidentally had wounded the meſentery, and the blood flowed from a vein that was tore; whereupon all the blood of the veins of the meſentery turned its courſe, and haſtened to the wound with unequal velocity; yet certainly for ſome ſmall time with a greater velocity than that of the arterial. I afterwards opened a vein with the lancet, a very rapid current of blood came to the orifice, but in a retrograde direction: for under the laſt wound the blood had loſt its motion, that is to ſay, between this part and that which was tore. But preſently the blood recovered its natural direction, although it moved but ſlowly and in ſmall quantity. The wound cloſed up without the leaſt mark, and the motion of the blood was ſuſtained with great ſwiftneſs, after the wound was healed. I opened an artery that contained but a few globules, whereupon the blood acquired an increaſed velocity, even a greater than the arterial blood generally hath. This experiment was a little neglected, buſineſs calling me elſewhere.

Exp. CLXVII. *On two frogs*, June 5.

The blood in the vein when I opened it had not the leaſt motion, but it preſently on opening the vein came to the wound both from the heart and from the inteſtines, with a velocity exceeding that of the arteries. The blood of an adjacent vein haſtened to the inciſion by an anaſtomoſis, in a retrograde direction; notwithſtanding the intercepting angles. The globules, as is uſual, with much precipitation flow from the orifice. After the blood ceaſeth running, the wound cloſeth up, by the means of a red grume binding the orifice, which is ſurrounded by a pale cloud.

Exp. CLXVIII. *On a frog*, June 6.

I tied up the aorta, notwithſtanding which bleeding as much increaſed the motion of the blood into the vein that was opened, and into thoſe which communicated with it, as if no ligature had been made.

Exp. CLXIX. *On a frog*, June 7.

I opened once more a vein, and obſerved the great velocity that bleeding creates in the venal blood: this operation haſtens it both from the heart and inteſtines, and the velocity that is created by this operation is very apparent, both in the vein that is opened, and in all others which have any communication with it.

I tied up at this time the aorta near the heart, and I opened another vein that was full of blood; whereupon this vital fluid moved with the ſame velocity in its natural direction as in a retrograde one, and the blood came to the orifice by all the veins that had any communication with that which was opened.

Exp. CLXX. *On two frogs*, June 18.

The blood had no motion in the vein when I opened it; after which I obſerved therein two contrary motions to ariſe, whoſe rapidity abated by degrees: the current returning from the part the neareſt the heart, preſerved its velocity longer than the other. The wound being cloſed I obſerved a tumor, of a ſubſtance ſomewhat like a vein, fixed round the wound, and in the orifice I obſerved a red grume that entirely filled it up.

Arteriotomy brings the blood to the wound with great rapidity; I had ſucceſs in it this day, although it is performed with difficulty in this ſpecies of animals, whoſe arteries are very ſmall, and alſo very thick. The motion of the blood ceaſeth ſuddenly, conſidering its rapidity.

A ligature on the artery doth not hinder the vein that accompanies it from giving blood when it is opened.

Exp. CLXXI. *On a frog*, June 26.

I obſerved nothing new; I opened a vein, and ſaw the rapidity with which the blood of the vein itſelf, and of all the veins communicating with it, was precipitated into the wound; the column returning from the heart in a retrograde direction, generally continues the longeſt, and is more rapid in its motion, and more copious and abundant. I obſerved again oppoſite currents to ſtrike on each other at the wounded part. I ſaw the blood loſe its motion by degrees, and a cloud to ſurround the wound, and cloſe it.

Exp. CLXXII. *On a frog*, June 28.

I performed arteriotomy on this animal; the blood had no motion in an adjacent vein, although it ran violently from the wound of the artery. By degrees the velocity of the arterial blood abates, and a row of globules come to the orifice only one by one. But I obſerved in this artery that the velocity began again to increaſe, and entire waves came again to the wound from the heart, with a great velocity. The blood having almoſt entirely abandoned the artery, what remained loſt all its motion.

Exp. CLXXIII. *On a frog that was pregnant*, July 3.

Arteriotomy ſucceeded in this experiment.

A true and oval aneuriſm aroſe in the artery, and the blood continued its motion into the artery with conſiderable ſwiftneſs; although it had no motion at all in the adjacent vein. At this time I opened the artery in the aneuriſm itſelf; the blood ran from the wound a long time, it came thither in its natural direction from the heart, and it came thither alſo from the inteſtine. This laſt column was the weakeſt, yet for ſome time it was carried into the wound, afterwards it had a librating motion and reſiſted the column that came from the heart, by which it was compelled to give place: this laſt column divided itſelf for ſome moments, one part paſſed into the wound, and was diſcharged from the artery; but the other continued its courſe in the artery: the wound preſently after cloſed up, and the motion of the blood was re-eſtabliſhed. I opened four times ſucceſſively the artery, and always with the ſame ſucceſs.

As the blood came from the heart with a leſs velocity, and perceiving the alternate jerks and accelerations proceeding from the contraction of the heart, I opened the vein that accompanied the artery, whereupon I found the velocity to recover itſelf in the artery, and the jerks or accelerated motions were then no longer perceptible. I repeated twice this experiment: as to the arteries it is difficult to know in what manner their wounds cloſe, becauſe they cloſe towards the meſentery, which is at too great a diſtance from the glaſs, and is ſeparated from it by the whole thickneſs of the membranes of the artery, which is pretty conſiderable.

The blood in the veins having loſt its motion I opened one of them, whereupon it was recovered: a new velocity was apparent in this vein and in all its branches, and alſo in the adjacent veins communicating with that which was opened by the lancet.

Exp. CLXXIV. *On a frog*, July 5.

I opened the vein with a pair of ciſers; by this means a larger orifice is made than when a lancet is uſed: the blood ran out of the vein in rapid whirling motions, and with a ſurpriſing velocity; the blood came to the wound both from the inteſtines and from the heart, but the velocity of this laſt column was the greateſt. In the adjacent arteries the blood preſerved its velocity, yet it was not ſo great as the torrent of blood which diſchargeth itſelf from the wounded vein, and which comes from the heart: notwithſtanding this velocity, the blood which flowed from the vein that was opened, began to abate in its motion, and the vein which I had opened cloſed up, whereupon the blood began to circulate again in its natural way, but the ſize of the vein was ſomewhat diminiſhed.

Exp. CLXXV. *On a frog*, the ſame day.

I opened an artery, and made a conſiderable large wound therein. The hæmorrhage was very great, but the part of the artery that was the neareſt the inteſtines was the firſt which left off the furniſhing blood, although it contained much: but this ſeldom happens. The column that was the neareſt the heart afterwards abated in its motion, and at laſt all motion ceaſed. A little before the motion ceaſed, I obſerved the motions *per ſaltus*, which gave an acceleration to the motion, and a cloud of globules were diſcharged from the wound. An hæmorrhage may be produced, by detaching from the artery the grume and miſt which ſhuts up the wound. At laſt the blood loſt all motion; during the time it was running from the artery it moved briſkly in all the adjacent veins.

Exp. CLXXVI. *On ſome frogs*, July 11.

Many of theſe animals had but very little blood in their veins; the globules moved very ſlowly, and bleeding brought but few to the wound.

In ſome other frogs that were more plethoric, the artery, when it was opened, gave blood, which threw itſelf into the orifice, both from the heart as from the oppoſite part. At laſt, both theſe torrents loſing their motion, a cloud ſurrounded the wound, and miſty thickiſh waves one on each other formed a tumor: the more exterior were the paler. An artery which I tore formed itſelf into a blind round cavity.

Exp. CLXXVII. *On a frog*, the ſame day.

I tore a vein, but no blood iſſued from it, and it formed a blind round cavity, full of red globules; afterwards I opened a vein by bleeding, the orifice that I had made being very ſmall ſoon cloſed up, and the motion of the blood became again as well eſtabliſhed in its natural courſe, as it was before the operation. I afterwards made a large inciſion in the ſame vein, nevertheleſs it cloſed up, after much blood had been diſcharged from it, in all imaginable directions, and under very acute angles; which to appearance ſeemed to be contrary to and reſiſt its motion. I ſaw better than uſual the red grume which cloſeth the orifice of the vein, whoſe circumference is of a paler colour. At the end of this experiment I cut all the vein, and the blood flowed from it abundantly.

EXP. CLXXVIII. *On a frog*, July 19.

I repeated this operation of bleeding many times ſucceſſively with the ſame ſucceſs. The blood which before in the vein had no motion at all, recovered it, and formed two contrary currents; the one came from the heart and the other from the inteſtines, and haſtily precipitate themſelves into the wound: By degrees the motion abated, and the wound cloſed. I obſerved the red grume of blood to fill the orifice, and even a little to extend itſelf beyond it. I ſaw again the effect of bleeding on the arterial blood, which had loſt all its motion. It was entirely at reſt in the arteries when I opened an adjacent vein, the blood had ran but a ſmall time from the vein before the arterial blood recovered its motion. Another time I opened the ſame vein in two places. The ſuperior inciſion a little retarded the current of the blood, which diſcharged itſelf at the inferior orifice, but did not entirely ſuppreſs it. I made this experiment to ſhew the effect bleeding may have, with reſpect to the ſuppreſſing of hæmorrhages.

Exp. CLXXIX. *On a frog*, the ſame day.

I obſerved almoſt the ſame phænomena. Bleeding accelerated the motion of the arterial blood; the wound in the vein cloſed, but there remained viſible a ſmall opening, and a few red globules acted on it as a ſtopple. When this opening became filled with this grume of blood, the regular circulation took place again in the veins. I obſerved alſo that bleeding accelerated the motion of the ſingle globules contained in the capillary venal plexus. I tore a vein with a pair of pinchers, the ſuperior extremity which came to the heart, and which furniſheth moſt of the blood in bleeding, gave at preſent none at all. It formed a ſort of blind conic cavity, full of red globules: the inferior extremity towards the inteſtines gave blood as is uſual at bleeding.

Exp. CLXXX. *On a frog*, July 24.

I wounded an artery, whereupon an extraordinary hæmorrhage enſued, the blood was thick and very inclinable to coagulate, it was brought to the wound in its natural direction and alſo in a retrograde one, for it returned alſo from the inteſtines. This blood divided into two oppoſite currents, which ſtrike againſt each other at their entrance into the wound. The globules that are diſcharged from the artery ſeparate themſelves the one from the other: afterwards there aroſe a red miſt, which by degrees diſappeared, the centre remained of a deep red, but the periphery became pale. The flowing of the arterial blood from the wound loſt at this time ſomewhat of his rapidity, and preſently after it entirely ceaſed, and the circulation took place in the artery in the following manner. The artery dilated itſelf at the wound. and formed an aneuriſm almoſt twice as large as the natural diameter of the artery. This aneuriſm was filled with a whitiſh miſt, like that which is obſerved externally on the wounds of the veſſels; through this miſt there paſſed two, and afterwards three or four ſmall ſtreams of red blood, and thus by degrees the current of blood through the artery was entirely re-eſtabliſhed. I obſerved the ſame in the veins, and now and many other times, I have obſerved that a white miſt poſſeſſeth part of the cavity of the vein that hath been opened, and that the globules make their way through this whitiſh and tranſparent coagulum, by which means the circulation in the vein afterwards recovered itſelf; I obſerved alſo that at theſe times the blood hardly ever returns in a full ſtream in the vein whoſe wound is cloſed up, and that the light through which the blood paſſeth is narrower even after the circulation hath recovered itſelf. There muſt be then reſident in the arteries and veins, ſome white gelatinous fluid; this fluid congeals round the exterior ſurface of the wounded veſſel, as I have before related, and a hæmorrhage returns, by nubbing off or otherwiſe taking away this kind of miſt. I verified this laſt experiment three times in the ſame frog and in the ſame artery, with the ſame ſucceſs. When the blood of this artery had loſt its motion I opened it above the firſt wound, whereupon the blood which came from the heart only recovered its motion, and none came from the inteſtines. A new velocity now ariſing in the blood, the current from the heart drove before it, the globules that were at reſt, put them into motion and carried them between the two wounds, and beyond the laſt inciſion. It is true, that this revived motion did not continue long; I opened afterwards and as expeditiouſly as I was able, an adjacent vein, whereupon the blood at the ſame time flowed from the vein and from the ſuperior wound in the artery with much rapidity, but the venal blood flowed more ſwiftly than the arterial. I obſerved in the vein two oppoſite currents, that which came from the heart was the firſt which ceaſed to move; I wiped off with a piece of linnen the miſt

that

that was ſormed round the vein, whereupon the hæmorrhage that was ſtopped returned again.

After the wound of an artery or vein, ſome mark and ſlit remains, it neither intirely cloſeth nor dilates, and it is very minute when it is made with a very fine inſtrument.

Exp. CLXXXI. *On two frogs*, the ſame day.

I tore a vein, and it gave blood, as is uſual in veins that are wounded.

I thought I ſhould have been able to obſerve in this experiment whether the motion of the arterial blood is in reality accelerated, by the opening of an adjacent vein, but I could not obſerve at this time any thing very convinceing.

Exp. CLXXXII. *On a frog*, July 25.

An artery being empty, I opened the vein that was adjacent to it. The part of the vein that was towards the heart gave blood, but no blood came from the part towards the inteſtines; the column which came from the heart at laſt ceaſing to flow, a whitiſh miſt ſurrounded the wound, and a red grume cloſed the cleft in the artery.

I obſerved attentively, what happened in the empty artery, whoſe adjacent vein I had opened; at firſt the globules, came in a ſmall number and deſcended by the artery, the number of globules increaſed by degrees, and at laſt the artery which was in a manner colourleſs, lax and pale, became large, ſwelled and full of blood moving ſwiftly, I at this time twice ſucceſsfully verified this experiment.

I afterwards tore a vein, but no blood was diſcharged from it, from the part that was towards the heart, I turned it back at the other end towards the inteſtines, whereupon this part ſwelled, and the blood filled this part, but none was diſcharged from it, it returned from thence as if it was repelled by this turning back and folding of the vein as it appeared to be by this experiment.

Exp. CLXXXIII. *On a frog*, the ſame day.

I obſerved for a conſiderable time the rapid motion of the arterial blood and the eaſy motion of that in the adjacent vein: preſently afterwards the motion of the blood was entirely loſt both in the artery and vein, and there remained in the artery only a few ſcattered globules. At this time I opened the vein that lay contiguous to the artery: the blood was diſcharged from it with great force, at laſt a whitiſh miſt ſtopped its further diſcharge. The arterial blood recovered by degrees its motion while the blood was running from the vein, it deſcended into the artery, and ſoon intirely filled it, dilated its light and paſſed through with a great velocity.

I tore a vein, the end towards the heart afforded much blood: I cut through a large vein; the part towards the inteſtines gave no blood, but blood came from the part towards the heart.

I tore an artery in order to obſerve if the phænomena differed from thoſe where an artery is cut. The part of the artery the neareſt to the inteſtine gave no blood, but much came from the part towards the heart; ſometimes it was diſcharged in a full ſtream, and ſometimes the ſtream was weak and in the form of a cone: this conical figure ſeemed to me to be owing to the coagulum of ſome inviſible fluid, occupying part of the cavity of the artery that was tore, and whoſe quantity increaſe towards the extremity of the artery; this increaſe, therefore, leſſened the column of blood paſſing through this coagulum; what confirmed me in this opinion was, that when I wiped the artery this torrent of blood became again cylindrical, and its diameter entirely uniform. A hæmorrhage in the artery, as well as in the vein, terminates always by the means of a whitiſh miſt ſurrounding the veſſel, haveing the centre filled with a red grume.

In this frog the two columns of blood which met at the wound, were of two different columns, that from the heart was of a fine purple, and that from the inteſtines of a paliſh yellow.

Exp. CLXXXIV. *On a frog*, July 26.

I opened a vein and obſerved every thing as uſual at this time. I wounded this vein in three different places: at laſt I cut it through; yet after a great loſs of blood the wound cloſed. The end of the vein towards the heart afforded blood plentifully, although in a retrograde direction; but the extremity towards the inteſtines (wherein the blood had its natural direction) gave leſs, and firſt ceaſed furniſhing any.

The artery which accompanied the vein, which was opened, being empty at the beginning of the operation, began to fill with blood, and the motion therein recovered itſelf with the uſual velocity.

The animal being now very weak, I bled it again, but no blood was diſcharged, and the motion of the arterial blood did no more recover itſelf.

Exp. CLXXXV. *On a frog*, the ſame day.

I opened three times a vein in this animal, it cloſed up every time, and the circulation was reſtored therein without the leaſt diſcompoſure.

The motion of the blood in the artery that accompanied the vein, which I opened, did not recover itſelf; it was almoſt empty: but preſently after it recovered without any aſſiſtance by bleeding, and both the blood and its ſwift motion in the arteries were reſtored. We muſt therefore be careful in engaging for the ſucceſs bleeding may have on the motion of the arterial blood.

Exp. CLXXXVI. *On a frog*, July 27.

There was in a manner no blood in the artery: I opened a vein, whereupon globules began to fall *guttatim* into the artery that accompanied it, and by degrees both the quantity of blood and its natural velocity were reſtored, during the time the blood flowed from the vein that was opened. But this phænomenon was not conſtant: for I opened another vein and drew a conſiderable quantity of blood from it; but the blood in the arteries did not recover its loſt motion. I obſerved again after the blood had ceaſed running from the wound, and after the inciſion was healed, whether the motion that had recovered itſelf in the vein had therein a greater or a leſs velocity, than it had before bleeding. I could perceive as to this matter no difference, and the globules ſeemed to me to move therein in an eaſy uniform motion.

Exp. CLXXXVII. *On a frog*, July 20.

This little creature was the ſtrongeſt I had met with: I opened an artery wherein the blood had a briſk motion: but how great ſoever this ſwiftneſs was, it was much increaſed after the artery was opened, the torrent going from the artery was too ſwift to be followed by the eye. The blood even in a retrograde motion returned from the inteſtines, with a velocity not at all inferior to that with which the blood came hither from the heart.

After a few minutes the velocity diminiſhed, a miſt ſurrounded the wound, the blood ceaſed moving retrograde from the inteſtines, the orifice cloſed, and there only remained the natural current coming from the heart, and which paſſed through the artery.

I obſerved an aneuriſm in the artery of this animal, wherein the blood was at reſt, when the motion of the blood in the artery was abated, and began to reſiſt every freſh wave coming from the heart I haſtened to open the vein that accompanied the artery. The blood for ſome minutes ran from the vein; and at this time the blood in the artery and in the aneuriſm recovered their motion, and circulated through the artery and vein; but the current was indeed ſmaller than natural. Preſently after the vein cloſed, the motion of the blood in the artery ceaſed, and there was therein but a ſmall number of globules, which had changed their direction and returned retrograde.

There was alſo another vein which accompanied the artery: I alſo opened this, and much blood was diſcharged from it. During the time the blood was runnng from the vein, it began again to circulate through the aneuriſm and the artery, with an increaſed velocity. The animal was not able to undergo all theſe loſſes of blood; theſe veins and the artery were exhauſted, and no more blood appeared, although I made a freſh wound in the vein. By this experiment it appears, that the veins may be exhauſted and emptied, without their parieties becoming contracted, in proportion to the loſs of blood.

Exp. CLXXXVIII. *On a frog*, Auguſt 6.

I was ſo fortunate at this time, as to find what I was ſeeking after; for I diſcovered many veins, and an artery of the meſentery, wherein the motion of the blood was but ſlow: as ſoon as poſſible I opened the vein which accompanied the artery. As I had now many veſſels under my view, I diſtinguiſhed better than ever the increaſed motion with which the blood moved from all theſe veins towards the inciſion. The column which returned from the heart had the greater velocity. The motion of the blood of three or four large veins became entirely retrograde, in order to come to the inciſion. After a few minutes all motion ceaſed in the veins, and the motion of the blood in the artery did not recover itſelf.

I created an aneuriſm in the manner ſet forth in the fourth ſection. I cut the artery tranſverſly in that part that was juſt under the aneuriſm. Nothing iſſued from it, and the whole aneuriſm remained full of blood, without dilating itſelf in the leaſt.

I took away the trunk of the artery, whereupon it formed a kind of cone, and no blood iſſued from it.

Exp. CLXXXIX. *On a frog*, the ſame day.

This experiment ſucceeded well; the artery was almoſt empty, there was ſcarce any ſingle globules contained therein, and theſe moved in a row at a diſtance from each other. I at this time opened the vein, the blood flowed briſkly from the wound, and while it was running the blood in the artery recovered its motion, and moved with a greater velocity both through the artery and its two aneuriſms.

I diſcovered again an artery lying near a vein, but I tried no experiment thereon; the motion of the blood was yet too rapid in the artery.

I was not more ſucceſsful with another portion of the meſentery: I obſerved there an artery, in which the velocity of the blood being diminiſhed, the alternate accelerations of the blood from the heart were apparent: this is always a ſign of the debility and weakneſs of the animal. I at this time opened the vein. The velocity of the blood in the artery was hardly increaſed, neither at the time the blood was running from the vein, nor after the miſt before taken notice of had cloſed the wound. It appears that this experiment but indifferently ſucceeds, when the animal becomes weak to a certain degree.

Exp. CXC. *On a frog*, September 20.

I took away the heart, the blood in a vein had no motion, I opened it and the blood was

diſcharged

diſcharged from it with as great a velocity as in the natural ſtate. Two oppoſite ſtreams threw themſelves into the wound; the one came from the heart, and the other from the inteſtines: I repeated twice this experiment with the ſame ſucceſs.

Exp. CXCI. *On a frog*, September 21.

I uſed this animal in many experiments, which I have related in the eighth ſection: I will only report the following:

I had cut the two principal branches of the aorta, and the arteries were found entirely empty, the blood having no motion through them. I at this time opened a vein, it gave blood abundantly for a conſiderable time, longer from the heart than indeed from the inteſtines. I obſerved two veins which were parallel to each other, *a e* and *c e*; they were a little inflected and joined at *e*. I opened the vein *c e* in *c*: there was between *e* and *c* a branch *b d*, which communicated with the vein *c e*. The blood had loſt its motion in the vein *b d*; but after the opening of the vein, the increaſed velocity from bleeding, gave the blood a power of moving from *a* by *e* into *c*, and that blood which had no motion in the vein *d b*, recovered it and moved briſkly towards the orifice by *b*. By degrees the motion of the blood recovered itſelf in an adjacent artery, it became full of blood briſkly circulating through it; afterwards it moved a little ſlower, and always in a direction contrary to its weight; and this motion continued fifteen minutes, at which time all motion being loſt I obſerved another portion of the meſentery; but the motion was every where at an end.

Exp. CXCII. *On a frog*, September 25.

The two principal branches of the aorta being cut tranſverſly, I opened a vein; and in this experiment and almoſt in all others which I made, the blood haſtened to the inciſion through all the veins which communicated with the vein that was opened: it moved to the orifice, both in a retrograde direction, as alſo againſt the force of its weight. The blood by degrees ceaſed to run from the wound, but the orifice remained gaping, and reſembled a creſcent. There remained entire in the vein only a ſmall path, above the inciſion. The blood entered this path and moved through it briſkly, moving alternately from the heart to the inteſtines, and from the inteſtines to the heart.

Exp. CXCIII. *On a frog*, September 27.

I cut off the two principal branches of the aorta of this animal; in ſix minutes afterwards I opened a vein: the blood rapidly came into the orifice from all the veins which had any communication with the vein that was opened, equally as if the animal had undergone no loſs; and a grume of globules cloſed the wound as uſual. During the time the blood was running from the vein, the arterial blood which had loſt its motion, by degrees recovered it, and moved briſkly from the inteſtines. Twenty-one minutes after the deſtruction of the aorta's, I opened again a vein and the blood haſtened, as before, towards the wound, by all the veins communicating with the vein that was opened, and alſo by all thoſe which were opened. All theſe numerous experiments eſtabliſh the following concluſions:

1. The motion of the blood is certainly accelerated by bleeding, as well in the vein that is opened as in thoſe which communicate with it (*a*); and alſo in the veins of the capillary plexus (*b*). When the blood hath loſt its motion, by opening the vein it recovers it (*c*), and the velocity it had before is increaſed by bleeding. The blood is determined towards the wound, as to a part whoſe reſiſtance is deſtroyed; for the ſame phænomena happen when the heart is taken away (*d*), or when a wound is made accidentally (*e*). The blood haſtens to the orifice, without regarding its natural direction of motion, and equally in a retrograde motion, as well as contrary to its gravity

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(*a*) Exp. 150, 152, 153, 154, 156, 158, 159, 160, 162, 163, 164, 166, 168, 169, 171, 188, 219, 224, 226. (*b*) Exp. 179. (*c*) Exp. 150, 154, 155. 158, 161, 167, 173, 178, 190, 191, 192, 193, 194, 227, 230, 231. (*d*) Exp. 149, 199, 220, 221, 223, 227, 228, 229, 234, 235, 236. (*e*) Exp. 166, 222.

gravity (*f*). Bleeding can therefore, excepting where there are valves, diſengage the heart and lungs.

2. The ſame phænomena riſe by arteriotomy, it accelerates in like manner the arterial blood to the wound, contrary to its natural direction (*g*), arteriotomy, and the opening of a vein differ only by the greater velocity the former hath.

3. Bleeding hath the power of reſolving the coagulated grumes and maſſes of the blood (*h*).

4. I ſhall now relate in order, the experiments which I have made, to determine the effect bleeding hath on the motion of the arterial blood. There are examples where this operation hath appeared to retard it (*i*); there are others where the effect hath been doubtful, and wherein it hath been difficult to decide whether bleeding retarded the motion of the arterial blood or accelerated it (*k*); but in the major part of the experiments bleeding I found accelerated it (*l*), or elſe it made it recover its motion when it had none before (*m*): it is true that ſometimes the arteries receive blood again,

(*f*) Exp. 150, 151, 152, 153, 154, 155, 156, 158, 159, 162, 164, 166, 167, 169, 170, 171, 174, 177, 178, 179, 184, 188, 189, 190, 192, 193, 194, 224, &c.
(*g*) Exp. 152, 154, 155, 156, 168, 170, 172, 173, 175, 176, 180, 187, 199, 201, 221, 222, 223, 226, 229, 231, 234.
(*h*) Exp. 150, 155.
(*i*) Exp. 153, 156.
(*k*) Exp. 162, 163, 174, 185, 186, 188, 189, 232.
(*l*) Exp. 163, 164, 166, 173, 181, 187, 189, 192.
(*m*) Exp. 163, 178, 182, 183, 184, 186, 194, 220, 227.

again, which recovers its motion without any aſſiſtance by bleeding (*n*); but this ſo ſeldom happens that it doth not at all weaken the experiments of (*l m*), as to this operation.

5. I have not a ſufficient number of experiments to determine how long after bleeding the change in the motion of the venal or arterial blood, continued after the wound of the vein was cloſed (*o*).

6. My experiments are ſufficient to ſhew the manner how the wounds of the veſſels cloſe up; they are filled with a tranſparent lymphatic fluid, equally ſurrounding the outſides of the wounded veſſel: the clift in the vein is filled with a clot of coagulated globules (*p*), the contraction of the veſſels hath no effect at all, ſince this clift or mark continues even after the circulation is entirely reeſtabliſhed (*q*).

7. My experiments do not ſufficiently determine the effect of bleeding in ſtopping hæmorrhages. It is true, that the ſpring of the blood from an artery became apparently weakened, by opening a ſecond time (*r*); and a ſecond bleeding weakened the ſtream that run from the firſt inciſion (*s*), but another experiment ſhewed (*t*) that the blood may be diſcharged

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(*n*) Exp. 92, 185. (*o*) Exp. 186. (*p*) Exp. 153, 154, 157, 160, 161, 163, 166, 167, 170, 171, 176, 179, 180, 182, 187, 194. (*q*) Exp. 156, 179, 180, 193, 199. (*r*) Exp. 147. (*s*) Exp. 179. (*t*) Exp. 180.

charged from a vein with a great velocity without any retardation of the blood flowing from an artery; therefore it remains a doubt, whether bleeding made with an intention to diminiſh a hæmorrhage acts in an hydraulic manner, or whether it doth not operate by an univerſal reduction of the ſtrength of the animal body.

SECTION. VIII.

Experiments in order to diſcover the cauſes of the motion of the blood independant of the heart.

Exp. CXCIV. *On a frog*, June 16. 1751.

I TOOK away the heart from this animal (*a*), before which I had a long time obſerved the circulation; notwithſtanding this violence the arterial blood continued its motion for half an hour compleat. I obſerved a veſſel which had two branches, the blood in them had a balancing and librating motion, it moved alternately from one of the branches to the trunk, and to the other branch, and alſo from the trunk to the two branches (*b*); this motion at laſt ceaſed, all the part becoming dry.

Exp.

(*a*) Dr. Remus reports this experiment, p. 59, and alſo two others of the ſame kind, which I have made, but not entered in my journal. (*b*) Exper. 66.

Exp. CXCV. *On two frogs*, July 17.

I cut the veſſels of the heart and ſeparated them from it. The motion of the blood continued in the arteries and in the veins for ſome time, but longer in the veins, even when the arteries were found empty, and conſequently immoveable.

Exp. CXCVI. *On a little fiſh*, July 19.

The blood moved conſiderably briſk in its natural direction, in the large as well as the ſmall arteries and veins, at the time when the heart had no motion at all, or the gills any action. I was willing to know if this was the effect of a ſyncope, or if the animal was really dead. I untied it and flung it into freſh water, but it did not recover; whereupon I was obliged to admit, that the blood continued in motion after the death of the animal.

Exp. CXCVII.

The red globules which diſcharge themſelves from the wound of an artery, and which are diſperſed between the laminæ of the meſentery, are attracted towards the parieties of the arteries where they collect themſelves. There muſt be ſome ſubſtance that is cellular in theſe places; becauſe we obſerve both the globules and bullæ of air to ſtop and remain fixed here.

Exp. CXCVIII. *On a frog*, Auguſt 30.

I took away the heart as expeditiouſly as poſſible, in order to obſerve whether the blood would continue its motion without this primary agent of the animal machine. I ſaw very diſtinctly the blood haſtening towards the heart, both by the arteries and veins: this motion of derivation continued two minutes. There was not any contraction, either in the arteries or veins. I ſaw in another frog the blood moving briſkly between the membranes of the meſentery.

Exp. CXCIX. *On a frog*, September 14.

I wounded at the ſame time both the vein and the meſentery, this membrane contracted itſelf, whereby there was formed a round orifice; but not one globule was diſcharged from it. The globules of the vein, as if they were repelled by the circular parieties of this orifice, return from it, and contrary to the natural direction of the circulation, enter ſome other vein, in order to move from the inteſtines.

Exp. CC. *On a frog*, the ſame day.

I obſerved an artery wherein were contained only a few globules: I made a wound in it; the globules haſtened towards this opening in the artery, even againſt their natural direction. The blood was no longer diſcharged from the wound in the vein, when the animal began to move and ſhake it: this effort made the hæmorrhage return. The orifice in the artery diminiſhed without the leaſt change or contraction.

Exp. CCI. *On a frog*, September 30.

This animal having been convulſed, only a ſmall quantity of blood now iſſued from the wound; which ſoon ceaſed, and the blood circulated in the vein in the natural order.

Exp. CCII. *On four frogs*, May 14, 1754.

Theſe animals preſerved many ſigns of life; and after I had taken away the heart, they ſee, they bring their eyelids over their eyes on moving a ſtick towards them, they breathe and dilate their noſtrils, as if they would ſmell.

Exp. CCIII. *On a frog*, May 30.

I cut off and took away one half of the heart, leaving only the auricle; notwitſtanding which it lived and jumped about ſome time.

Exp. CCIV. *On a frog*, June 22.

I ſaw very ſatisfactorily the motion of the blood depending on its own weight; I elevated the whole meſentery, placing it higher than the body of the animal; ſoon after which the arteries and veins cf this large membrane appeared empty, pale, and thin; becauſe all the blood of the meſentery ran back towards the heart by its own weight. Afterwards I ſuffered this membrane to deſcend, ſo as to become lower than the body of the animal; whereupon all the veſſels filled again with blood, and the veins were of a deep red colour,

lour, and this change was created by the blood's falling again into the veſſels, and becauſe its weight had now no power to empty them. Preſently after this having obſerved with a microſcope the blood as it deſcended in the veins, according to the direction of its weight. I inverted the board, ſo as to make the weight of the blood oppoſe this current which I had before obſerved: immediately all the blood in the veins became immoveable, its weight haveing deſtroyed all circular motion.

The blood having its free motion in the arteries and veins of the meſentery, I tied up the aorta near the heart, whereupon the blood loſt its motion in the arteries: there was not one globule in motion, excepting a ſmall number that were returning to the heart. But the motion of the blood in the veins ſuffered very little by the ligature on the aorta; and it continued in a briſk motion, both with and without the aſſiſtance of bleeding. It ſeemed to me remarkable, that the blood of a large vein, inſtead of continuing its direction towards the heart, changed this direction, and turned its courſe by a large branch which communicated with it, in order to come to the wound that I had made in a vein near the inteſtines. The ſame thing happened on opening another vein, although the artery which accompanied this vein received no more blood from the aorta, which I had wounded.

Exp. CCV. *On a frog*, June 7.

I once more tied up the two great branches of the aorta, going out from the trunk at a ſmall diſtance from the heart, and from which all the arteries of the animal take their riſe. The veins of this frog were very full of blood; I opened one of them, whereupon the blood haſtened from all parts and by all the branches of communication towards this opening, in order to come into the wound, and to diſtribute themſelves between the laminæ of the meſentery.

Exp. CCVI. *On two frogs*, June 18.

I obſerved the motion of the blood in the arteries and veins; I tied up at this time the aorta, whereupon the blood loſt its motion in the arteries, and there only remained a ſort of librating motion. I cut off the ſilk ligature, and the motion in the arteries recovered itſelf. But the ligature on the aorta made no alteration in the motion of the venal blood; for it was diſcharged from the inciſion I had made in a vein with the ſame rapidity: neither is the motion of the venal blood, depending on its weight, at all changed by tying up the aorta. By elevating or depreſſing the meſentery I made the globules of blood either aſcend or deſcend, *ad libitum*, in a large vein of the meſentery.

Exp. CCVII. *On a frog*, June 20.

I obſerved the circulation which was as regular as poſſible, when I tied up the two great branches of the aorta, and alſo the large veins of this animal, at which time I opened one of the veins of the meſentery. The blood ran from the wound as if no part had been out of order, the vena cava ſuperior continued its contractions, the animal opened and ſhut its eyes, ſwelled its lungs, it jumped, and all this at a time when the heart had loſt all its motion.

Exp. CCVIII. *On a frog*, June 26.

I obſerved the motion of the blood that aroſe from its weight, this I obſerved in a vein of the meſentery, I could alter the direction of the blood as I pleaſed by inverting the board. I made the blood deſcend from any point I deſired, either towards the inteſtines or towards the heart. But this was not ſo eaſy to be done in the arteries wherein the motion of the blood is much more conſtant and rapid.

I obſerved a briſk motion in the globules of blood, that were diſcharged from the vein that was opened, and were diſperſed beween the meſentery.

Exp. CCIX. *On a frog* June 28.

I tied up the two great branches of the aorta, whereby the motion of the venal blood became weakened, but it was not ſuppreſſed, and I have learned by my experiments, that this motion doth not continue long in an animal living in torture. I obſerved very diſtinctly the conſtriction of the large veins, that is to ſay, of the vena cava inferior, of the veins of the liver, and of the large vein of the ſuperior extremities. This tying up of the arteries appears to weaken the animal; but yet it remains alive, for it ſhuts its eyes, and it ſurvives a much longer time after a ligature is made on the arteries, than after the taking them off.

Exp. CCX. *On a frog*, July 3.

I tied up the artery of the meſentery, and I opened a vein in this membrane: it gave blood as copiouſly as it would have done if no ligature had been on the artery: the blood came to the inciſion both from the heart and from the inteſtines.

No blood is diſcharged by the wounds of the meſentery; though it moves round the orifice that is made therein. The contraction of the venæ cavæ continue, although there is a ligature on the aorta.

Exp. CCXI. *On a frog*, July 11.

No blood was diſcharged from a laceration of the meſentery, but it lay in a maſs as above, Exp. 210, round the borders of the wound.

Exp. CCXII. *On a frog,* July 24.

The venal blood had a rapid motion, in this ſtate its weight had no power on its motion, but as ſoon as the velocity abated, its weight prevailed and the blood moved as I would have it, either towards the heart, or towards the inteſtines, or into other veins, provided I gave it a declining poſition for that purpoſe.

I afterwards elevated the meſentery of this robuſt animal, whereupon all the blood went from it, and its veſſels became thin and pale, the next moment I ſuffered it to deſcend to its former ſituation, and all the veſſels became filled with blood.

The blood that was immoveable in an artery was put into motion by its weight which carried it downwards.

I verified once more this influence of weight on the venal blood, and I determined its direction as I pleaſed, by giving it a declining poſition, and by this power of gravity only I made it paſs through the gelatinous miſt, which cloſed up the orifice of a vein.

Exp. CCXIII. *On a frog,* July 25.

Having cut through the meſentery and alſo a large vein, not one ſingle globule of blood was diſcharged from this orifice in the meſentery, the blood as if it was repelled from the borders of this orifice moved backwards, and diſtributed itſelf between the coats of the meſentery.

Exp. CCXIV. *On a frog*, July 26.

I obſerved a motion that was conſiderably ſwift in the globules which were diſperſed between the coats of the meſentery. This motion could not be attributed to any power of their weight.

Exp. CCXV. *On a frog*, July 27.

I ſaw again this motion in the red globules, which I called a motion of fluidity, not being able to aſcribe it to weight. Theſe globules move externally by the ſides of the veins which have been opened, they move in ſome inviſible cellular matter, as in a kind of canal parallel and contiguous to the vein, on both ſides this veſſel.

Exp. CCXVI. *On a frog*, September 20.

I ſuddenly took away the heart; the librateing motion of the arterial blood in a manner continued for ſome ſeconds: in the veins the blood which had but a very weak and languiſhing motion, ſoon loſt it, but bleeding recovered it.

I obſerved that the globules which were diſperſed between the coats of the meſentery were guided by the laws of their gravity and weight. I obſerved alſo therein ſomewhat of an attractive power, before mentioned, Exp. 215. The blood that was extravaſated on the ſide of the inteſtine, followed the ſame tract as it reaſcended againſt its own weight.

Exp. CCXVII. *On a frog*, the ſame day.

The arteries were intirely empty, and in the veins there was but little blood, which had but a very ſlow motion; when I took away the heart from this animal, it moved from one branch to another, and again it entered the trunk for many minutes, but there was ſo ſmall a quantity of blood in the veins that its motion could not have a conſiderable velocity. This motion did not appear to proceed from any derivation of the blood, for as the globules were carried from the wound they moved from the inteſtines; neither was this motion any effect from weight.

Exp. CCXVIII. *On a frog*, September 21.

The arteries were empty, and in the veins there was but little blood, whoſe motion was ſlow: I took away the herat. I obſerved but a ſmall motion in the venal blood: I opened at this time a vein, whereupon the blood haſtened from all parts to the orifice, as if the heart had been unhurt, all the branches communicating with the vein I had opened furniſhed it with blood until the wound was cloſed, and the blood ceaſed running from it.

I obſerved three ſorts of motion in the venal blood of this animal, it had one motion directed by its weight; it had alſo an oſcillatory motion, whereby the blood was carried backward and forward. The third was a ſort of attractive motion, which I obſerved in the globules that were between the membranes of the meſentery: theſe globules re-aſcended on the external ſurface of the artery and vein, and in their deſcending again they formed a parabola.

This frog lived in this ſtate, it had the uſe of viſion, it opened its eyes and ſhut them, frequently moving its eyelids, it endeavoured to jump: after a few minutes all remains of motion ceaſed.

Exp. CCXIX. *On a frog*, the ſame day.

I obſerved in an artery the rapid motion of its blood, and alſo in a vein the eaſy motion thereof: I took away the heart, ſeparating it with a pair of cizars; the method I always uſed. The blood of the artery began to loſe all its motion, and the vein diſcharged its blood by the large wound of the vena cava. By degrees this copious bleeding brought blood into the artery, which had a motion contrary to its weight.

Fifteen minutes after the loſs of the heart, the animal jumped very briſkly, and threw itſelf from the top of the town-houſe.

Exp. CCXX. *On a frog*, September 22.

The motion of the blood was very viſible, but the blood in the vein was retrograde when I took away the heart. The blood in the arteries had a great velocity and diſcharged itſelf from the wound of the aorta. The venal blood had the ſame, it briſkly returned from the meſentery and inteſtines and was diſcharged by the cava. Buſineſs intervening, put an end to this experiment.

Exp. CCXXI.

I had obſerved the motion of the blood in two veins, and in an artery when I deprived the animal of its heart. The blood returned with great rapidity by the artery towards the heart. In the vein it continued its courſe by the inteſtines, where the animal had received a wound. An oſcillatory motion enſued in the arteries; for the blood one moment moved towards the inteſtines, and returned from thence towards the heart. Whatever might have been the cauſe of this motion, it certainly was not owing to any gravitating power from the weight of the blood.

Exp. CCXXII. *On a frog*, September 23.

This experiment ſucceeded well: I obſerved under the microſcope an artery and two veins, and the motion of their blood was in a good ſtate when I took away the heart of the animal. The blood preſently returned back in the arteries, and haſtened, as I have always obſerved, to return towards the heart; but its motion was a little ſlower indeed than uſual.

It moved alſo towards the heart by the vein; ſome moments after a librating motion enſued, and the blood aſcended and deſcended alternately into the artery. In the vein it had this balancing motion above half an hour, and it had not ceaſed theſe dodging motions, when other affairs required my attention.

The globules which were between the coats of the meſentery aſcended againſt their own weight. All this time the animal lived without heart and auricles, it ſwallowed food; this indeed is the ordinary employ of theſe animals: it alternately ſwelled and emptied its lungs, and gave all ſigns of life, and half an hour after threw itſelf from the window.

I had obſerved in the ſame ſubject the motion of the blood depending on its weight.

Exp. CCXXIII. *On a frog*, September 24.

I diſcovered the great vein of the meſentery; I took away the heart, I obſerved an oſcillation in the vein, the blood moved thereto from the branches into the trunk, and returned again into the branches. I at this time opened one vein, and afterwards another. The blood always haſtened to the wound without any difference in its direction, and ran into the inciſion of the vein, and from thence into the meſentery.

I was willing to try if this motion of derivation would continue and prevail againſt any gravitating power the weight of the blood ſhould ſet up againſt it; I therefore managed it ſo, that the current that ran into the orifice of the veins ſhould be contrary to this weight, and I found that this motion of derivation was by far the ſtrongeſt, and that the weight had no power to reſiſt it. The motion of the blood continued above fifteen minutes after the loſs of the heart.

The blood of the veins having loſt their motion, the greater part of their globules degenerated from their red colour and became yellow.

Exp. CCXXIV. *On a frog*, the ſame day.

The arteries were empty, but the veins contained much blood, which had a retrograde motion towards the inteſtines: there appeared ſomewhat like ſtrangulations in the veins when I took away the heart. A large vein appeared in the meſentery, which received three other veins. In the principal trunk the blood deſcended as its weight directed it; ſometimes nevertheleſs it re-aſcended and ran ſometimes the whole length of the vein, and ſometimes it went to the neareſt branch into which it entered.

Of the three branches which communicated with this trunk, the ſuperior one was nearly parallel; it was almoſt void of blood; its blood had a ſort of librating motion. The globules which did not half fill the inferior part of the vein, moved towards the inteſtines, and returned from thence alternately with a conſiderable velocity. The middle branch was in general horizontal, but yet it was a little winding and re-aſcending. Notwithſtanding this diſadvantage, the blood moved thereto from the trunk for twelve minutes: it aſcended to it and deſcended again from thence preſently after with a conſiderable velocity.

The loweſt branch had a deſcending poſition, the blood ſwiftly moved to it from the trunk: its weight aſſiſted it; but preſently after it returned from thence with as much ſwiftneſs towards the heart, againſt its weight. I now therefore inverted the board: the blood notwithſtanding continued moving upwards into the large vein, and alſo againſt this power of its weight into the middle branch; it thus aſcended thereto with ſufficient velocity thirteen minutes after the loſs of the heart. The blood that was diſcharged between the coats of the meſentery, contiguous to the inteſtines, had a dodging librating motion, but did not leave the inteſtines; and this motion was then more briſk than that of the arteries: I repeated this experiment and obſerved again the blood to re-aſcend againſt its own weight, and to move from the trunk of the vein into its branches.

Exp. CCXXV. *On a frog*, September 25.

This experiment alſo ſucceeded very well; the blood had a free motion in the arteries and veins: when I took away the heart, in an artery of the meſentery that was under the glaſs I obſerved the blood moving ſwiftly to the heart, and the arteries which were very full of blood, became entirely empty: the part which firſt became empty was that towards the heart, and the part which was neareſt the extremities was the laſt: when this artery was almoſt empty and it contained but a few globules, theſe globules returned towards the inteſtines, and alternately again moved towards the heart. This librating motion continued ſixteen minutes: the venal blood returned towards the heart but ſlowly, and it ſeemed entirely to loſe all motion: I therefore at this time opened a vein, whereupon the blood of ten veins communicating with that which I had opened, haſtened towards it and was impetuouſly diſcharged from the wound, five minutes after the loſs of the heart. At laſt the blood ſtopped, at which time, that is to ſay, ſixteen minutes after the time above-named the blood in the vein moved to and from the heart in a ſwift librating motion.

But after ſome moments reſt, the venal blood recovered its motion: it had a variable and ſwift motion, upwards and downwards, from the inteſtines to the heart, and from the heart to the inteſtines.

The globules which had ran between the two coats of the meſentery, and lay at ſome diſtance from the cellular ſubſtance of the arteries, approached each other and aſcended again towards the artery: as ſoon as they came into contact with the artery they recovered ſome increaſed velocity in this narrower ſpace: but they deſcended again and diſperſed themſelves. The velocity of this motion diminiſhed fifteen minutes after the loſs of the heart, from ſome cauſe or other; but certainly it was not from any gravitating power from the weight of the blood.

Twenty-ſeven minutes after the loſs of the heart, the librating motion of the arterial and venal blood was yet briſk, the arteries were yet full of blood: as for the veins they contained but a few globules, and they were at a diſtance from each other. It is almoſt unneceſſary to aſſert, that theſe motions were independent of any contraction of the veſſels, and that a ſmall number of globules moved in the veſſels, whoſe oppoſite pariety was too diſtant from them to touch them.

Thirty minutes after the loſs of the heart, the blood with which the veins were again filled, loſt its motion. There remained yet in the arteries a librating motion. Neither weight, or any convulſion of the nerves could any more recall the motion of the blood.

During all this time the heart continued to beat, and the animal had a free uſe of all its ſenſes (*a*).

(*a*) Having compared the copy with the original, I found I had cut the two great branches of the aorta, without taking away the heart; but this will make no difference with reſpect to the reſults I ſhall draw from this experiment.

Exp. CCXXVI. *On a frog*, the ſame day.

On opening the belly of this animal, I found the blood in the artery had no motion but that of two veins, which were at the ſame time under the microſcope, had yet a librating motion, compounded of the natural and retrograde direction. At this time I took away the heart; the blood in the artery did not recover its motion; but in the vein it moved with a great velocity to the wound in the vena cava, that had been made by taking away the heart: ſome time after it returned from thence towards the inteſtines. Five minutes after the heart was taken away, I opened a vein: the blood ran to the wound, both from the heart and from the inteſtines; the two contrary currents ſtroke, as uſual, on each other. All the veins communicating with that which was wounded, ſent their blood towards the wound. When the venal blood had for ſome time flowed from the wound, the arterial blood recovered its motion in its natural direction towards the inteſtines. A little time after the wound cloſed up, and the blood continued its courſe in the part of the vein that was entire. This motion alſo abating, I changed this part that was under the glaſs, and took another 15 minutes after the loſs of the heart, when I diſcovered other veins and arteries; the arteries were empty but the veins were full of inmoveable blood. I opened one of them, the blood was diſcharged from it as uſual, and was carried thither, both from the veins towards the heart, as from thoſe towards the inteſtines: this motion was almoſt as briſk as in an animal in health. But in its turn it began to abate, and all motion entirely ceaſed 28 minutes after the heart was ſeparated from the aorta.

Whether this motion is called by the name of fluidity, or attraction, or by any that may be thought proper; it is certain, it depended not on the weight of the blood: for the blood had an equal velocity in re-aſcending againſt its weight, to come to the opening in the vein, as when it deſcended to come to it.

Exp. CCXXVII. *On a toad whoſe belly was of an orange colour*, September 26.

The ſeaſon being advanced, and frogs being now obtained with difficulty, I was willing notwithſtanding to verify ſome of my experiments, concerning the motion of the blood which was independent of the heart. I did not fear obtaining animals of this kind, that were larger and of a more hardy and ſtronger nature than frogs. It is true, we have a natural averſion to them; and they with more violence than frogs ſpurt out their urine againſt thoſe which offend them: but this was all the harm they did me, and they are in other reſpects more proper for experiments than frogs.

I obſerved the blood in an artery and vein of the meſentery to move perfectly equal, and the two currents were contrary to each other; the veſſels were well filled, and the motion rapid: when I cut through the two great branches of the aorta, the blood of the meſenteric artery ceaſed its motion immediately, and alſo that of the capillary venal plexus loſt its motion. But the vein continued to bring back the blood to the heart; and this it did for twelve minutes, with ſome ſmall returns towards the inteſtines, intermixed with the natural motion. The motion of the blood ceaſeing in this vein, I diſcovered another which aſcended perpendicularly; this carried its blood to the heart for ſeventeen minutes againſt its weight. This motion did not depend on derivation: for to avoid this ſuſpicion I had not deſtroyed the heart, therefore the extremity of the vena cava was not opened; neither could it be ſaid, that the blood was brought to the heart, as to a veſſel that had been opened by any ſection at the beginning of the aorta: for the heart in theſe experiments furniſhed but a ſmall number of waves, after which nothing is diſcharged at the riſe of the great artery.

During all this time the heart continued beating, it remained in its place with the veins, to which I had done nothing. I ſet the animal at liberty, it ſhook itſelf and endeavoured to make its eſcape: this motion forced a wave of blood from the heart; a long time afterwards the animal eſcaped.

Exp. CCXXVIII. *On a frog*, the ſame day.

The motion of the blood was regular and briſk, when I ſeparated the heart from the great branches of the aorta. The blood in the arteries had a retrograde motion, and moved towards the heart for ſome minutes. In the veins it alſo moved retrograde for a few ſeconds of time, but ſlowly.

I produced an artificial aneuriſm, in which the blood ſettled and formed a maſs; ſo that above and below the aneuriſm, the artery contained only rows of ſingle globules. I ſaw with pleaſure theſe globules return from the inteſtines, to join this maſs of globules: but at the oppoſite extremity of the aneuriſm other globules forſook this maſs of their own kind, and joined themſelves to a conſiderable large maſs of immoveable blood that was in the part of the artery which was nearer to the heart. The motion of theſe globules was briſk, and continued after the blood of the other veſſels had loſt its motion.

Ten minutes after the deſtroying of theſe large arteries, theſe globules themſelves alſo loſt their motion.

I conſidered with myſelf what might be the cauſes of this motion; it was not owing to any inviſible contraction of the aneuriſm; for in contracting a tumor full of blood, inſtead of driving the blood from it, thoſe globules would not have been received which returned to it from the inteſtines; and its contraction would have compelled them to move forwards towards the extremity, according to the natural direction of the arterial blood. The heart could have no effect on this motion, becauſe its communication with the arteries was abſolutely intercepted by deſtroying the large branches of the aorta; and the blood of the aneuriſm moved towards the heart, contrary to the direction this organ would have given it.

Neither was this motion a motion of derivation, neither was it created from any gravitating weight of the blood; therefore I thought I could only aſcribe the cauſe of this motion to ſome attractive power, whereby the globules are drawn to that part where there is the moſt blood collected. I was very deſirous to repeat this experiment.

Exp. CCXXIX. *On a frog*, September 27.

I created an aneuriſm and cut off the two great branches of the aorta; the blood of the artery of the meſentery preſently loſt its motion, and the blood of the vein continued its motion ſlowly to the heart. Six minutes after the deſtroying the great branches of the aorta, I opened the vein. The blood was conveyed as in an animal alive, through all the veins which communicated with that which was wounded, and ſo on to the wound itſelf; and the arterial blood recovered motion. The wound being cloſed, I obſerved a librating motion in a vein which united two venal trunks. The blood went one moment from the left trunk to the right, the next moment it returned from the right to the left. I thought I ſaw the vein which I had cut through, draw in the blood that had ran between the coats of the meſentery, and diſcharge it again alternately.

By degrees, after the wound of the vein was cloſed, the motion of the venal blood became very active, and the veins which were at a greater diſtance brought back their blood into their trunks, until they became entirely empty, and the trunk filled with blood. All motion began now to be languid, but the ſmall quantity of blood that was yet remaining in the veins, had a librating motion, compounded of the direct and retrograde motion. Twenty-one minutes after deſtroying the great arterial trunks, I once more opened a vein, whereupon the blood returned into the wound of the vein from all thoſe which had any communication with it; and even it was brought thither from veins that were empty, to which conſequently veins at a greater diſtance muſt have furniſhed this blood, and it was diſcharged from the wound as uſual.

This ſecond wound being cloſed, the librating motion continued in the vein of communication of the two venal trunks. The blood moved by this middle vein, ſometimes into one of the great veins, and ſometimes into the other. Thirty minutes after the deſtroying of the great arteries, it ſeemed to me probable, that this motion which had continued ſo long, was owing to attraction; this I judged, by reaſon of the alternate ſolicitation the blood of the middle vein underwent, from the larger quantity of blood contained in the two veins, to which it communicated. It is certain, that for thirty-ſix minutes there remained a balancing dodging motion in this vein of communication.

EXP. CCXXX. *On a pregnant frog,* the ſame day.

I deſtroyed the two great branches of the aorta; the blood returned in a retrograde direction towards the heart for a conſiderable time: ſometimes it had its natural motion towards the inteſtines. I opened a vein and the blood violently threw itſelf into the wound. But I could not ſee what I ſought after; and this experiment did not ſatisfy me.

EXP. CCXXXI. *On a frog,* September 29.

I had again the misfortune to wound a vein with the hook; by which accident the animal almoſt loſt all its blood: nevertheleſs, I obſerved ſome ſingle globules to preſerve their motion for ſome time in the artery. Bleeding equally produceth the ſame effect in the motion of the blood, as when the heart performs its duty; but I have not been able to ſatisfy myſelf with reſpect to the abſorbing of the blood into the veins. In this ſtate the animal ſwelled its lungs, and relaxed them; it looked about, it dilated its noſtrils, and vigorouſly jumped away when it was at liberty.

Exp. CCXXXII. *On a frog*, September 29.

I diſcovered the venal plexus of the meſentery, and the arteries which paſs over it. I cut off the two great branches of the aorta, at which time I opened a vein: I did the ſame ten minutes after the loſs of the arteries; whereupon the blood was violently carried into the wound of the vein; it moved thereto from all the branches communicating with the vein that was opened, but the motion of the arterial blood did not recover itſelf.

Exp. CCXXXIII. *On a frog*, September 30.

The arteries were empty, becauſe the animal had been confined without food three days in a box: the blood in the veins had not any motion; it had a ſmall librating motion in a vein, which by its communication joined two trunks: and ſometimes the blood moved into one of the trunks and ſometimes into the other. At this time I cut off the two great branches of the aorta; whereupon the motion of the blood in the arteries, which was loſt, recovered itſelf, and globules moved into them, whoſe number and velocity increaſed by degrees; and this blood moved towards the heart, which was a direction contrary to the gravitating power from its weight. In an adjacent vein the blood aſcended in the ſame manner, and moved into a larger trunk. I obſerved a remarkable librating motion in the blood that was extravaſated, between the coats of the meſentery. There was a maſs of blood attached to the inteſtine, and alſo another maſs of globules in the centre of the meſentery. I obſerved an alternate motion between theſe two maſſes of globules; it was detached from the inteſtines, and moved to the centre of the meſentery, and preſently after it returned back and attached itſelf again to the extravaſation of the inteſtines. I obſerved a very remarkable phænomenon in the venal plexus of the meſentery; that is to ſay, the motion continued therein ten minutes compleat, after deſtroying the aorta's, and at the time when the blood in the large veins had loſt its motion, I obſerved ſome ſingle globules at a conſiderable diſtance from each other, which reaſcended towards a venal trunk, and which were carried into a vein of two or three globules diameter.

EXP. CXXXIV. *On an orange colour toad,* the ſame day.

The blood in the arteries and veins had a regular motion, when I cut off the aorta's. I had the misfortune to wound the auricle. The arterial blood did not immediately recover its motion; but after five or ſix minutes I ſaw it deſcend in its natural direction towards the inteſtines. In the veins alſo the blood recovered its natural motion, and was carried towards the great trunks, and towards the heart with a velocity almoſt equal to what is natural.

The motion began to be languid when I opened a vein. The blood came ſwiftly from all parts into the wound, and was diſcharged between the coats of the meſentery. At this time I cut croſs the vein under the wound, whereupon I obſerved a whitiſh border ſeemed to terminate this wound, and not one drop of blood was diſcharged from it.

I obſerved the blood of this blind cavity to have a librating motion with the blood of the vein, for it deſcended towards this blind cavity; but it was repelled from it, and it aſſcended again into the vein to avoid it, but this dodging motion ſoon loſt its celerity. I obſerved alſo that the blood which had ran between the coats of the meſentery, aſcended as well as deſcended, but I could not obſerve that any blood was abſorbed or drawn again into the vein that I had cut tranſverſly. I had ſome doubts with reſpect to the 230th experiment, and was apprehenſive of ſome error.

Exp. CCXXXV. *On an orange colour toad,* October 1.

In the arteries and veins the blood had a briſk motion, when I cut off the two great branches of the aorta. The motion of the blood in the venal plexus was ſoon ſuppreſſed, but in the large veins the blood continued its courſe towards the heart. The motion of the arterial blood continued regular, and had a conſiderable celerity for twenty minutes. The globules of the blood of this animal was of a lively red colour.

All theſe experiments concur in proving,

1. That after the heart is taken away, or a ligature is made on the aorta, or after its two great branches are deſtroyed, whereby conſequently, the continuation of the blood is interrupted between the heart and the reſt of the body, and after the heart is intirely rendered incapable of imparting the leaſt motion to the blood; yet the motion of the arterial blood continues (*b*) even for a conſiderable time, for 15 (*c*) for 20 (*d*) and 30 (*e*) minutes. During all this time there exiſts then ſome cauſe of this motion of the arterial blood, which is independent of the heart. As this is the caſe it is not ſo very ſurpriſing, that life with the uſe of the ſenſes, and of the muſcles in like manner may be continued, without the leaſt aſſiſtance from the heart (*f*).

2. The motion of the venal blood, with as much certainty preſerves or recovers itſelf by

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(*b*) Exp. 193, 196, 197, 199, 201, 220, 221, 222, 223, 226, 227, 229, 230, 231, 232, 234, 235, 236.
(*c*) Exp. 224. (*d*) Exp. 236. (*e*) Exp. 196, 226.
(*f*) Exp. 203, 204, 208, 210, 219, 223, 228, 232.

bleeding, notwithſtanding a ligature, or the deſtruction of the aorta, or of the heart *(g)*. This motion is ſuſtained even in the capillary plexus of the meſentery (*h*). It hath ſeemed to me, that the motion is better preſerved in the veins than in the arteries (*i*).

3. I endeavoured again to diſcover the cauſes of this motion, which is independent of the heart, I diſcovered one of theſe cauſes, which is derivation, where the current of the blood is carried to the part where the reſiſtance is diminiſhed; this cauſe, which increaſeth the motion of the venal blood in living animals, which often recovers it when it is loſt, and which gives a motion to the arterial blood: By the experiments of the 7th Section this motion hath the ſame power on the blood without the leaſt aſſiſtance from the heart; that is to ſay, after the heart is taken away, or after the aorta is tied up, or after the two large branches of it are cut off. The opening *(k)* of a vein or ſome other wound of a large venal veſſel (*l*) ſeldom fails to accelerate the blood in the veins, or to recover it when loſt. Derivation produceth this effect 16 (*m*), 21 (*n*),

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(g) Exp. 169, 192, 194, 196, 197, 199, 206, 207, 208, 210, 211, 218, 219, 220, 221, 222, 223, 225, 226, 227, 228, 230, 231, 232, 233, 234, 235, 236.
(h) Exp. 214.
(i) Exp. 196, 205, 207, 218, 220, 227, 228, 230, 235.
(k) Exp. 268, 164, 190, 192, 194, 206, 207, 208, 211, 217, 219, 224, 226, 230, 231, 232, 233, 235.
(l) Exp. 199, 205, 220, 221, 222, 223, 227, 233, 235.
(*m*) Exp. 226.

21 (*n*), and 28 (*o*) minutes after the power of the heart is intirely deſtroyed. Bleeding hath the ſame effect on the arteries as it hath in a healthy animal, where the heart hath its natural power, it recals its motion, and bringeth blood to them; ſo that the globules move therein in a full ſtream (*p*). Single globules are put into motion by this operation; and altho' they do not fill the light of the artery, yet they move on, and come to the inciſion (*q*). Arteriotomy hath the ſame effect on the arteries (*r*) as opening a vein hath on the veins, it recalls, without any aſſiſtance from the heart, the motion of the arterial blood towards the part where a wound, or the total deſtruction of the great branches of the aorta hath made an opening which reſiſts leſs the current of the blood than the intire parieties of an artery that has ſuffered nothing.

I call here force of derivation, a force which ſhews its effects, and whoſe cauſe I am ignorant of, whether it is a latent contraction of the veſſels or ſome other power leſs known. Its power prevails over that of gravity (*s*).

4. Another cauſe giving a motion to the blood without the heart, is weight. My experiments ſhew it acts on the blood of a living animal; and that it determines its direction, without regarding the natural direction of the circulation

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(*n*) Exp. 194, 230. (*o*) Exp. 227. (*p* Exp. 192, 194, 227, 230. (*q*) Exp. 154. (*r*) Exp. 199, 201, 221, 222, 223, 226, 229, 231, 234. (*s*) Exp. 224, 227.

circulation. It acts on the venal blood (*t*), and determines it toward the baſe of a perpendicular, eſpecially when the circular motion is ſlackened and abated (*u*). It hath leſs power (*x*) in the blood moving in the arteries, unleſs the motion of the blood is decreaſed (*y*) or is intirely at reſt. It acts on the ſtrayed globules, and carries them towards the lower part of the meſentery.

5. But we muſt neceſſarily admit, among the motive faculties of the blood, another cauſe appearing both in the veſſels, and in the ſtrayed globules, intirely different from weight and derivation; ſince it acts equally againſt the former of theſe powers (*z*), as it evidently (*a*) overcomes the latter (*b*). It is independent on the heart, for I have obſerved it after I had deprived this organ of all communication with the reſt of the veſſels. I call this cauſe attraction, becauſe the greateſt part of theſe phænomena are effectively made towards ſome object not contiguous, and which appears to determine them. It hath appeared to me that the blood is attracted by the membranes of the animal body, as it is alſo by the blood itſelf; for the globules are drawn to the part where there is a maſs of their own kind.

This attraction of the firſt kind, is obſerved 1. Towards the cellular parieties of the large arterial and venal veſſels. The blood here collects

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(*t*) Exp. 205, 207, 209, 213, 219, 223. (*u*) Exp. 213. (*x*) 88, 209. (*y*) Exp. 117. 235. (*z*) Exp. 215, 216, 217, 218, 222, 223, 225, 226, 227, 228, 235. (*a*) Exp 225. (*b*) Exp. 218, 228, 229.

collects itſelf into a maſs (*c*); it comes hither from diſtant parts (*d*) of the meſentery, and with a conſiderable velocity (*e*) it follows the parieties of the arteries, and aſcends by them againſt their weight (*f*), and it doth not leave them. The ſame takes place with reſpect to the parieties of the inteſtines (*g*). I have often obſerved that the borders of the meſentery, when it was cut, ſerve as an obſtacle to the blood of a wounded vein, by reſtraining it, ſo that not one drop leaves (*h*) theſe borders.

2. I apprehended I had found this cauſe after I had obſerved that the globules of the blood approached each other, and joined themſelves to maſſes of globules of their own kind, which they did both in the veſſels, and alſo when they were ſtrayed between the membranes of the meſentery (*k*). I have already mentioned the almoſt conſtant motion of the venal blood towards the trunks (*l*) after the heart had loſt all its power over it, and alſo this oſcillation that is ſo frequent in the veſſels of communication.

(*m*) I alſo make uſe of the name of attraction without pretending to penetrate into the cauſe of this motion, and this name is with me no more than a name I make uſe of to ſignify a kind of motion, whoſe mechanical

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(*c*) Exp. 90, 198. (*d*) Exp. 98, 226. (*e*) Exp. 226. Experiments 199, 209, 215. appear to belong to this. (*f*) Exp. 216, 219. (*g*) Exp. 217, 225. (*h*) Exp. 200, 211, 212, 213, 214. (*i*) Exp. 229, 230, & 54. (*k*) Exp. 234. (*l*) Exp. 218, 226, 228, 230, 234, 235, 126. (*m*) Exp. 145, 230, 234, &c.

cauſe I am ignorant of, and which I ſhould be extremely glad to find out.

6. We may reckon alſo among the cauſes of the motion of the blood that is independent of the heart, The nervous irritation (*n*). I have obſerved the blood very often to recover its motion, either by ſome irritation or ſudden motion, by which means I have obſerved a hæmorrhage to return. But I cannot ſay, that after having very often irritated the nerves of the animal, I have ever obſerved the number of pulſes to increaſe, and often the circulation received no change thereby (*o*). I am much inclined to attribute the phænomena which I have ſeen to ſome mechanical motion, which would equally make the blood diſcharge itſelf from the veſſels of a dead ſubject, provided it was ſufficiently fluid.

7. The ſuction of the capillary veſſels is not by my Experiments, confirmed. The blood is as often drawn into the trunks (*p*) of the veſſels (*q*) as it is into the branches, when the heart is deſtroyed, which is intirely contrary to the idea of a power, which ſhould draw the blood into the capillary veſſels. It would be very eaſy to ſhew, that a power of this nature would deſtroy the circulation by creating a retention of the blood in theſe veſſels, which ſhould be carried from them, to return to the heart.

(*n*) Exp. 66, 117, 138, 201, 202, 228. (*o*) Exp. 69, & Exp. 489, of the 11. Memoire on Irritability. (*p*) With reſpect to the arteries, Exp. 205, 82. (*q*) With reſpect to the veins, ſee No. 50.

F I N I S.